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Rev. 07/10/02

SUPERFUND DIVISION
REMEDIAL ENFORCEMENT RESPONSE BRANCH

FIVE-YEAR REVIEW REPORT

SITE NAME: Cannelton Industries

INITIAL & DATE

RPM: R.CM 8/12/04 R.CM 8/19/04

FIVE-YEAR REVIEW COORDINATOR (Rosita Clarke): RCM 8/12/04

SECTION CHIEF: DB. 8/13/04

JAMES N. MAYKA: DB. for J.M. 8/13/04 JM 8/19/04

RICHARD C. KARL: for RK 8/19/04

RETURN TO: Rosita Clarke

PHONE# 67251

COMMENTS:

(EPA:JD:02/02/99)

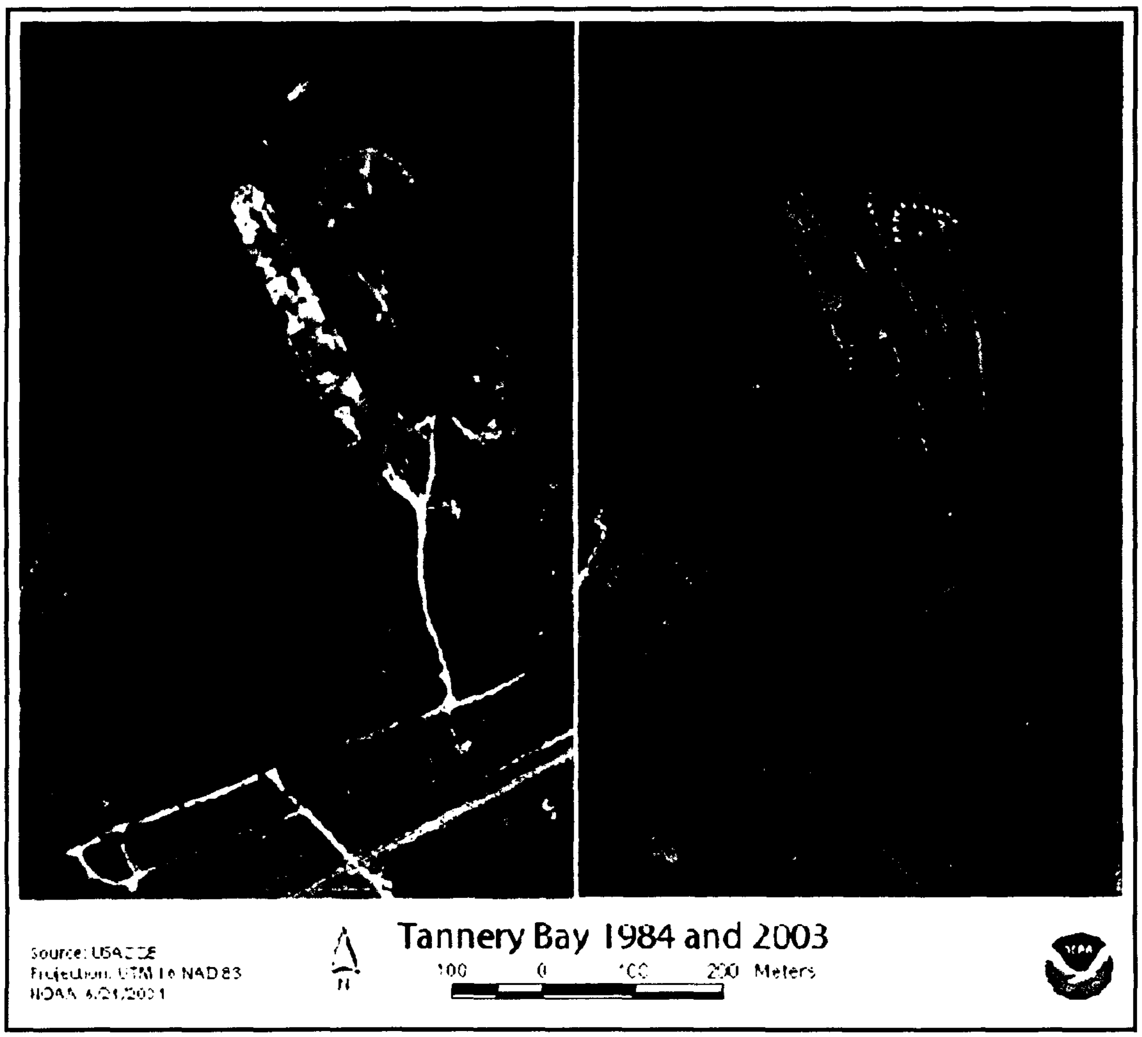
First Five-Year Review Report

For Cannelton Industries, Inc. Site

Sault Ste. Marie, Chippewa County, Michigan

August, 2004

PREPARED BY:
U.S. Environmental Protection Agency
Region 5
Chicago, Illinois



Approved by: Date:

8/30/04

Richard C. Karl, Acting Director
Superfund Division

Five-Year Review Report

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List of Acronyms

AOC	Administrative Order on Consent
AWQC	Ambient water quality criteria
Bgs	Below ground surface
CFR	Code of Federal Regulations
City	City of Sault Ste. Marie, Michigan
COC	contaminants of concern
CRA	Conestoga-Rovers & Associates
ERT	Environmental Response Team
FS	Feasibility Study
GLNPO	Great Lakes National Program Office
IC	Institutional Controls
MCL	Maximum Contaminant Levels
MDEQ	Michigan Department of Environmental Quality
MDNR	Michigan Department of Natural Resources
MSU	Michigan State University
NCP	National Contingency Plan
NOAA	National Oceanic and Atmospheric Administration
O&M	Operation and Maintenance
OMP	Operation Maintenance Plan
PRP	Potentially Responsible Parties
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RPM	Remedial Project Manager
Site	Cannelton Industries Site
SOW	Statement of Work
UAO	Unilateral Administrative Order
U.S. ACE	United States Army Corps of Engineers
U.S. EPA	United States Environmental Protection Agency
USGS	United States Geological Survey

Executive Summary

The assessment of this first five-year review for the Cannelton Industries Site found that the remedial action implemented in 1999 is functioning as intended and is being protective in the short-term of human health & the environment. Long term monitoring is taking place to ensure that long-term protectiveness is achieved at the site. The remedial action implemented at the Site included excavation and off-site disposal of contaminated soils and tannery waste materials from the former "Barren Zone (B)", Southern Shoreline of Tannery Bay, and Western shoreline (Zone A). Sediments were left in place in Tannery Bay for natural recovery. Long-term biological monitoring is taking place to verify protection of human health and the environment.

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site name *(from WasteLAN)*: Cannelton Industries, Inc. Site		
EPA ID *(from WasteLAN)*: MID980678627		
Region: 5	State: MI	City/County: Sault Ste. Marie/Chippewa
SITE STATUS		
NPL status: **X Final** Deleted Other (specify)		
Remediation status (choose all that apply): Under Construction Operating **X Complete**		
Multiple OUs?* YES **X NO**	**Construction completion date**: 09 /27 / 1999	
Has site been put into reuse? YES **X NO. Reuse discussions with the City are taking place.**		
REVIEW STATUS		
Lead agency: **X EPA** State Tribe Other Federal Agency		
Author name: Rosita Clarke-Moreno		
Author title: Remedial Project Manager	**Author affiliation:** U.S. EPA	
Review period:** 10 / 23 / 2002 to _08_ / _19_ / 2004		
Date(s) of site inspection: 06 / _08_ / 2004		
Type of review: X Post-SARA Pre-SARA NPL-Removal only Non-NPL Remedial Action Site NPL State/Tribe-lead Regional Discretion		
Review number: X 1 (first) 2 (second) 3 (third) Other (specify)		
Triggering action: X Actual RA Onsite Construction Actual RA Start at OU#____ Construction Completion Previous Five-Year Review Report Other (specify)		
Triggering action date ***(from WasteLAN)***: 06 / 08 /1999		
Due date ***(five years after triggering action date)***: 06 / 08 / 2004		

Issues:

No issues were found as a result of this review that affects the current protectiveness of the remedy. Deed restrictions on property could affect long-term protectiveness if not implemented in the future. Other issues documented, are for improvement of site reuse and redevelopment.

1. Deed Restrictions on property use have not been implemented
2. NPL Partial Delisting for parcels A, B, E needs to be completed
3. Redevelopment for the parcels where goals have been met.

Recommendations and Follow-up Actions:

1. Implement required deed restrictions on property once final decision on reuse is made.
2. Pursue the completion of the partial NPL desisting
3. Continue discussions with City and property owner to achieve goals for land reuse.
4. Continue monitoring activities to ensure long-term protectiveness.

Protectiveness Statement:

The remedy implemented at the Cannelton Site for the upland soils (zones A, B, and E) currently protects human health and the environment as source materials have been removed and residual contamination is below the site-specific cleanup levels that were established to ensure protection of human health and the environment.. However, there remain uncertainties with regard to long-term protectiveness of the remedy for zones C, Wetlands, and D, Tannery Bay. Insufficient data has been collected to date that would allow U.S. EPA to make a determination of long-term protectiveness for these areas. Laboratory geochemical studies were used to infer the stability of contaminants in wetland soils; however, the bioavailability of the COCs in wetland soils to wildlife receptors never was measured under fluctuating environmental conditions. Therefore, the long-term protectiveness of the remedy for wetland receptors remains uncertain. Spatial analysis of sediment deposition patterns during the past two decades support the assumptions in the Amended ROD that Tannery Bay is a net depositional area for sediment and the wetlands of Tannery Point are encroaching on Tannery Bay over the areas of contaminated sediment. However, additional questions remain regarding the effectiveness of the observed sedimentation and wetland encroachment on the anticipated decrease in bioavailability of site COCs.

The following actions need to be taken for the Wetlands:

- continue surface water sampling and additional rounds of groundwater sampling; and
- conduct bioavailability monitoring to confirm whether contaminants in wetland soils are entering the foodchain.

The following actions need to be taken for the Tannery Bay:

- continue surface water sampling and sediment sampling; and

continue biological monitoring to collect sufficient data to support trend analysis of the bioavailability of COCs in Tannery Bay sediments. Collection of this data will facilitate an evaluation of the effectiveness of the remedy in protecting human health and benthic organisms and wildlife inhabiting Tannery Bay and utilizing river areas adjacent to the Cannelton Industries site.

Long-Term Protectiveness:

Long-term protectiveness for Wetlands and Tannery Bay will be verified in the next Five Year Review.

Other Comments:

The current owner of the property applied for funding under the Great Lakes Legacy Act (GLLA) for sediment source removal. If funded by the Great Lakes National Program Office (GLNPO), the proposed dredging project would go beyond that required in the ROD Amendment and if it is properly designed and properly implemented the biomonitoring component of the Superfund required O&M Plan should verify a significant decrease in bioavailability of COCs. The EPA Superfund program would consider this to be a betterment of the environment. The Superfund program would need to evaluate the success of the remedial actions under the GLLA to determine whether the projected betterment protectiveness is achieved.

Five-Year Review Report

I. Introduction

The purpose of five-year reviews is to determine whether the remedy at a site is protective of human health and the environment. The methods, findings, and conclusions of reviews are documented in Five-Year Review reports. In addition, Five-Year Review reports identify issues found during the review, if any, and recommendations to address them.

Region 5 of the United States Environmental Protection Agency (EPA) has prepared this five-year review pursuant to Section 121 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Contingency Plan (NCP) (40 Code of Federal Regulations (CFR) Part 300). CERCLA 121 states:

> *If the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site, the President shall review such remedial action no less often than each five years after the initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented. In addition, if upon such review it is the judgment of the President that action is appropriate at such site in accordance with section [104] or [106], the President shall take or require such action. The President shall report to the Congress a list of facilities for which such review is required, the results of all such reviews, and any actions taken as a result of such reviews.*

The U.S. EPA interpreted this requirement further in the National Contingency Plan (NCP); 40 CFR Section §300.430(f)(4)(ii), which states:

> *If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after the initiation of the selected remedial action.*

EPA has conducted a five-year review of the remedial actions implemented at the *Cannelton Industries, Inc.* site in Sault Ste. Marie, Michigan. This review was conducted for the entire site from October 2002 through July 2004 by EPA, NOAA, and Cyprus Mines Corporation. Cyprus Mines Corp. is a subsidiary of Phelps Dodge, the current owner and Respondent to the Unilateral Administrative Order for the Site. This report documents the results of the review. NOAA and consultants for Cyprus Mines Corporation, PRP for the site, provided analysis of data in support of the five-year review. NOAA provided analysis and technical support under an Inter- Agency Agreement with EPA.

This is the first five-year review for the ***Cannelton Industries, Inc. Superfund Site***. The triggering action for this review is the date of the Remedial Action Construction Start date, as shown in EPA's WasteLAN database: June 8, 1999. The remedy implemented at the site left hazardous substances, pollutants, or contaminants above levels that allow for unlimited use and unrestricted exposure in specific areas (zones) of the site.

II. Site Chronology

Chronology of Site Events	
Event	**Date**
Initial discovery of problem or contamination	1978
NPL listing	August 30, 1990
EPA Removal Action, Response to fires within the Barren Zone, trenches were dug to mitigate recurring fires	June 11 - July 1, 1988
Unilateral Administrative Order (UAO) to Conduct PRP Removal Action	May 25, 1989
PRP Removal Action, installation of sprinkler system and fencing of the Barren Zone	May 1989 - April 1990
Administrative Order on Consent (AOC) for second PRP Removal Action	September 6, 1991
PRP Removal Action to protect shoreline along the Barren Zone and extend the fence in the Site.	September 1991 – January 1992
Remedial Investigation/Feasibility Study complete	June 1989 - October 1990
ERT Additional Field Studies	1991 and 1992
FS Addendum Completed	July 1992
Record of Decision signed	September 30, 1992
AOC for Remedial Design and PreDesign Studies	April 12, 1993
Field work for Pre-Design Studies took place	September 1993 – Summer 1994
Administrative Order on Consent (AOC) for removal action	October 4, 1994
PRP Removal Action to extend shoreline protection along the rest of the site along St. Marys river, east and west of the Barren Zone.	October 1994 – September 1995
Pre-Design Studies Report Completed, approved	January 5, 1995
30 % Design for Remedy	May 1995
Alternative Remedy Proposal by PRP	June 5, 1995
ROD Amendment	September 27, 1996
Modifications to Remedial Design AOC/SOW	April 4 and April 15, 1997
Remedial Design Start	May 14, 1997
Baseline BioMonitoring Event	June - September 1997
Sediment Stability Study	July 31, 1998
Michigan State University Soil Studies	November 1997
Remedial design complete	December 30, 1998
Unilateral Adminsitrative Order (UAO) for Remedial Action	February 18, 1998
On-Site construction/remedial action start	June 8, 1999
Consent Decree for Past Costs	July 28, 1999
Construction completion date (PCOR)	September 27, 1999
Construction Completion Report	December 16, 1999
Operation & Maintenance Plan Approved	June 2000

Chronology of Site Events	
Event	**Date**
First Post Remediation Biomonitoring Event	June - September 2000
First Monitoring Event	June 2000
Second Monitoring Event	November 2000
Interim RA Report	June 2002
Community Meeting: Five-Year Review/Partial Delisting	October 2002
Third Monitoring Event	December 2003
Site Inspection/ Field Reconnaissance for 3rd Biomonitoring Event	June 8, 2004
First Five Year Review Report	August 2004

III. Background

Physical Characteristics

The Cannelton Industries, Inc. (Site) is located along the south shore of the St. Marys River in the Upper Peninsula of Michigan, in Sault Ste. Marie, Chippewa County, in the NE 1/4 of Section 11, Soo Township (T47N, R1W). Figure 1 depicts the location of the Site. The Cannelton Site occupies approximately 75 acres, bounded by the St. Marys River to the north; 4th Avenue and the Soo Railway to the south; 18th Street to the west; and 12th Street to the east. Figure 2 shows a map with site features and delineation/boundaries.

The Site is physio-graphically divided into two distinct areas by a small bluff located adjacent to South Street on its south side. This bluff constitutes an elevation change of approximately 12 feet. The lower area, north of South Street, is adjacent to the St. Marys River at an elevation generally less than 610 feet mean sea level. The upper area south of South Street is typically at an elevation ranging from 630 to 640 feet. The lower area is divided further by a smaller bluff, with about 6 feet of relief, which may represent the former St. Marys River shoreline, as it existed prior to industrial activity in the area. This smaller bluff is evident across the site and runs basically parallel to South Street and the two-track in the western portion of the site. Most of the area north of this smaller bluff is wetland and is located within the 100-year floodplain, with an elevation of 3-to-5 feet above average river level, which is 600.2 to 601.2 feet above sea level. The remaining areas of the Site are not in the 100-year floodplain.

Other pertinent site features include a small bay located adjacent to and northeast of the Site called Tannery Bay. A former commercial coal dock forms the eastern side of Tannery Bay, while the southern and western sides are bordered by the Site. The peninsula adjacent to Tannery Bay that forms its western shoreline is referred to as Tannery Point and is primarily wetland. Four ponds exist on Tannery Point and are called Dump Pond, Middle Pond, Long Pond, and Beaver Pond. Tannery Point originated as part of a large pier that was filled in with scrap lumber and sawdust.

Significant surface water features occurring at or near the Cannelton Site are the St. Marys River; wetlands along the River; Seymour Creek, which enters the St. Marys River approximately 200 feet west of the Site; and Ashmun Creek, which enters the River about a half mile east of the Site. The St. Marys River is the sole outlet for Lake Superior, the largest fresh water lake in the world, and forms a connecting channel to Lake Huron, the third largest fresh water lake in the world.

A former tannery operated on the site from the early 1900's to 1958 when the tannery burned down. The site, as shown on Figure 2, shows the site delineated by different zones or areas from A to E. The former plant area was located in Zone E. Zone B was an area called the Barren Zone and was the area of highest concentration of tannery waste. Zone A, also referred to as the Western Shoreline, had minimal tannery activities, but is part of the property. Zones C and D are along the shoreline and consist of the wetland area and Tannery Point and Bay.

The Cannelton Site is also located within the boundaries of the St. Marys River Area of Concern, which is one of 43 areas on the Great Lakes that was identified in 1985 by the International Joint Commission for development for a Remedial Action Plan (RAP). The St. Marys River was selected because 9 of the 14 beneficial uses identified under the Great Lakes Water Quality Agreement were impaired. The St. Marys River Area of Concern is a joint effort between the United States and Canadian Governments. The Site is one of the primary sources of contamination on the United States side of the Area of Concern.

Land and Resource Use

The Site was the location of the former Northwestern Leather Tannery Company. Prior to this, a saw mill operated on the north eastern portion of the Site. Tannery Point originated as part of a large pier, which extended out into the river. The pier created the western shoreline of Tannery Bay, and it appears that the saw mill filled in much of the western side of the pier with scrap lumber and sawdust. The pier also stopped some of the discharged tannery waste from going downstream and allowed the waste to fill in on the pier's upstream side. This combination of filling activities created what is now called Tannery Point and accounts for the fact that Tannery Point has evidence of tannery waste as well as saw mill waste material.

Since 1958, when the tannery burned down, the buildings were demolished and the property has been unused. The current land use surrounding the Site is residential and light industrial. There are approximately 400 single-family residences located within one-half mile of the Site boundary, the majority of which are south and west of the Site. The nearest residence is a small building containing several residential units adjacent to the Site, directly south of Tannery Bay on South Street. McKinley Elementary School is located approximately 100 feet south of the western portion of the Site across 4th Avenue. The nearby residences and the school are connected to the City's municipal water system.

Currently, the property remains unused after cleanup was completed in 1999 and local zoning is designated for industrial land use. The 20-Year Master Plan for the City of Sault Ste. Marie designates future land use in the site area, for general industry and high-density residential use in the area from 16th Street to 18th street and from 4th Avenue to shoreline. There is a strong interest by the City of Sault Ste. Marie and the current land owner to reuse portions of the property for commercial, light industrial and residential uses. Plans are underway to achieve the reuse and redevelopment goals for the Site.

The St. Marys River connects Lake Superior and Lake Huron via the Soo Locks and is the boundary between the United States and Canada. Currently, the St. Marys River is a major navigational channel and a drinking water source for Sault Ste. Marie, Michigan and Sault Ste. Marie, Ontario, Canada. The source for Sault Ste. Marie's municipal water supply is the St. Marys River intake, located approximately one mile upstream of the Cannelton Site. The groundwater beneath the Site is not currently a drinking water source nor is it expected to be in the future.

Most of the shore areas at the Cannelton Site are wetlands. The St. Marys River is the major hydrologic influence on the wetlands. Some water also originates from a storm sewer that probably services the nearby residential building located on South Street in the eastern portion of the Site.

The largest wetland area is located on Tannery Point. The Tannery Point wetlands overlay sawmill and tannery waste, which is typically high in nitrogen and is commonly sold as fertilizer and soil conditioner. The wetlands on Tannery Point include four ponds. The ponds appear to have formed from decomposition and compaction of the fill material, i.e., sawdust and lumber scrap. A habitat survey conducted in 1992 (EPA 1992) evaluated wildlife habitat use of Tannery Point and Tannery Bay. The habitat evaluation was accomplished through vegetation and small mammal inventories, a fish survey, general wildlife observations, and soil profiles. The wetlands are primarily forested wetlands and emergent cattail marshes. The majority of the trees in the wetland area consisted of Balsam poplar and speckled alder. The understory and groundcover primarily was comprised of Reed canary grass, an invasive species, and goldenrod and horsetail. Tree cores taken from trembling aspen and red ash had mean ages of 22.2 years (s=5.2, n=30) and 29.5 years (s=8.1, n=22) respectively. During a 3-day field investigation, 41 bird species, 9 mammal species, and 4 amphibian species were observed using the site. Species observed included white-tailed deer, ground hog, green heron, wood thrush, mallard, Canada goose, and beaver. Habitat utilization included: nesting of waterfowl (Canada Goose), breeding of all amphibians observed, feeding of most species observed, and permanent residency of many of the species observed. The diversity of habitat is partially believed to result from the activity of beaver. Evidence of periodic clearing of wooded areas by the beaver can be found throughout many areas of the site. There are no known occurrences of Federal or State listed endangered or threatened natural plant communities, or natural features at the Cannelton Site.

Rather than base remedial efforts solely upon contaminant levels, the impact of remediation on this apparently diverse and well-used wetland environment was taken into consideration. The age of the trees, a gauge of wetland maturity, was weighed against the information generated on environmental risk. Removal of contaminated wetland soils was thought to be more harmful to the established forested wetland (and wildlife use of the area) than allowing some level of contamination to remain in place.

Recreational use of Tannery Bay appears to be limited to fishing and waterfowl hunting. Tannery Bay is shallow, so boating and swimming would be difficult, although wading is possible, but would be difficult because of the thick soft sediment and the prevalence of wood and bark debris from historical sawmill operations.

The Site is underlain by a shallow aquifer, which consists of glacial deposits and is primarily characterized as silty sand, though there are also site-wide variations, such as a linear deposit of gravels and cobbles, a fairly continuous layer of sand and gravel above bedrock, and a thin layer of clay serving as a discontinuous confining layer in some of the deeper wells along the river. The bedrock underlying the unconsolidated deposits, the Jacksonville Sandstone, has considerable topography at the Site. There is a buried bluff in the bedrock located near South Street, which causes the depth of bedrock to vary from approximately 30 feet south of South Street to approximately 60 feet near the river. In spite of this, there is a continuous aquifer connecting the upper and lower areas of the Site and the St. Marys River. The depth to the water table ranges from approximately 8-to-23 feet in the plant area and 1-to-7 feet in the area north of South Street.

The Site-wide groundwater gradient is towards the St. Marys River. Vertical gradients are downward in the southern portion of the Site, indicating a recharge zone, and upward in the northern portion, indicating a discharge to the river. The average groundwater velocity for the Site was calculated to be 0.19 feet/day or 70 feet/year. The velocity may vary based on the different soil types found across the site.

History of Contamination

The Northwestern Leather Tannery Company operated until 1958, when the tannery was destroyed by fire. During its period of operation (from 1900 to 1958), the tannery processed raw cowhides using a sophisticated and multi-step process that transformed raw animal hides to a finished leather. The plant had no sewage system other than three drains, which included pipes and open ditches, running north to the shores of the St. Marys River to what was referred as the waste discharge zone. According to historical records and interviews with former employees, no liquid waste was discharged to the east, west, or south of the plant. During busy times of operation, the plant might have discharged up to 132 chemical vats per day, or approximately 250,000 gallons per day, through the drainage system. Historical aerial photographs indicate that waste was discharged directly to St. Marys River and adjacent wetlands.

The primary tannery waste discharge area covered a 4-acre area north of South Street and includes an irregularly-shaped area of approximately one acre, which prior to cleanup, was partially devoid of vegetation and contained multi-colored soils and tannery waste residues. This area is referred to as the Barren Zone as depicted in Figure 2. The Barren Zone was the location where solid waste byproducts of the tanning process were dumped.

The Western Shoreline area, Zone A, was also used as a dump site for barrels and general wastes from the tannery. According to former employees of the tannery, approximately two truck loads of plant wastes were disposed of per day. These wastes were typically burned after disposal. The former Tannery Plant and waste discharges are shown on Figure 3.

The wastes discharged from the tannery in the area adjacent to the river included metals, cyanide, sulfide, calcium carbonate, salts discharged as brine solutions, and various leather finishing solutions such as shellacs, thinners, formic and carbolic acids, formaldehyde, ammonia, octoalcohol, and other alcohols. Chromium is the primary metal known to be disposed. Tannery waste has been exempted as a listed hazardous waste under the Resource Conservation and Recovery Act (RCRA).

Aerial photographs indicate that some of the tannery waste deposited on the St. Marys River shoreline eroded over time. Both this eroded material and material disposed of during the plant's operation were likely carried by the river downstream and deposited along the western shoreline of Tannery Point and downstream in Tannery Bay.

Initial Response

Prior to the U.S. EPA's involvement, environmental sampling from 1978 through 1988 at the Site had partially delineated the nature of contamination. The Michigan Department of Natural Resources (now MDEQ) performed sampling in 1978, 1979 and 1980, and the property owner periodically conducted sampling during the period from 1979 to 1986. In 1987, the United States Geological Survey (USGS) installed a monitoring well at the Site. The majority of the historical on-site sampling had been limited to the area in or adjacent to the Barren Zone. A minimal amount of groundwater, surface water, and sediment sampling had also been performed.

The U.S. EPA's removal program was first involved at the site in 1988 due to recurring fires at the Site. The fires, which were located within the Barren Zone, reportedly occurred spontaneously during the dry summer months and had been increasing in intensity. U.S. EPA responded and excavated five trenches within the Barren Zone, in order to delineate the source of the fires, reduce methane build-up, and to disperse heat build-up within the soils.

In May 1989, the U.S. EPA issued a Unilateral Administrative Order (UAO) to the PRPs who were the property owners, Cannelton Industries, Inc., and Algoma Steel Corporation, its parent company. The UAO directed the PRPs to install a sprinkler system to help reduce the incidence of fires, to further investigate the cause of the fires, and to construct a shoreline stabilization system in front of the Barren Zone to prevent waste materials from eroding into the river. The sprinkler system was installed immediately, and rip-rap was installed along the shoreline in front of the Barren Zone in November 1989. The investigation did not determine the cause of the fires and once the sprinkler system was installed fires did not occur again at the Site.

In September 1991, an Administrative Order on Consent (AOC) was signed with U.S. EPA that required the PRPs to fence a larger area of the Site to prevent access to contaminated areas and to extend the shoreline stabilization both east and west of the existing rip-rap to protect adjacent shoreline areas from erosion. In 1995, Cannelton Industries, Inc. under another AOC, completed the shoreline stabilization from the western shoreline to the tip of Tannery Point.

The Site was listed on the NPL on August 30, 1990. Special Notice Letters were issued to PRPs requesting that they conduct the Remedial Investigation/Feasibility Study (RI/FS) for the Site. Since no settlement was reached with the companies, U.S. EPA funded the RI/FS. The field work required for the RI/FS took place from June 1989 to October 1990. Additional field work was conducted by U.S. EPA's Environmental Response Team (ERT), Edison, New Jersey, in October 1991 and May 1992. The first study involved additional sediment and soil toxicity tests and benthic macroinvertebrate studies. The May 1992 field activities consisted of a habitat survey of the wetlands on site and some preliminary mapping of the extent of tannery waste in Tannery Bay. Reports for each of these studies were prepared by ERT and can be found in Site files.

The RI Report was published in September 1991. A Baseline Risk Assessment was completed in October 1991. The Feasibility Study (FS) was published for public review and comment in April 1992. An FS Addendum, was completed in July 1992.

Basis for Taking Action

The sampling prior to the Remedial Investigation (RI) suggested soil samples from the Barren Zone were contaminated with cadmium, chromium, copper, nickel, lead, zinc, arsenic, and cyanide.

The RI results showed the primary contaminants at the Site to be metals. The concentrations of inorganic compounds in soils and sediments at the Site closely followed the historical land use and the currents of the St. Marys River. The highest values were associated with the former tannery drains and discharge areas, while elevated levels of metals were also present in the soils along the western shoreline of the Site where general refuse was dumped, in the former plant area, along the shoreline east of the main discharge area, and in the adjacent wetlands. Based upon their distribution within the soils and sediments, the following metals were found to be elevated at the Site: chromium, arsenic, lead, mercury, barium, and cadmium. Chromium was the most wide-spread inorganic contaminant in the soils and sediments at the site. Following are the maximum concentration (in mg/kg) detected in soils and sediments:

	Soils	Sediments
Arsenic	3,600	29.6
Barium	10,300	202
Cadmium	341	26.1
Chromium	328,000	40,000
Lead	10,100	603
Mercury	25	2.3

The groundwater and Surface water at the Site were not widely impacted from the former tannery operations relative to MCLs and AWQC respectively.

Human Health Risk Assessment
Based on total estimated exposures and toxicity information current at the time of the ROD(1992), total carcinogenic risk levels to exposed populations from chemicals of potential concern at the Site ranged from 1.5×10^{-3} to 7.5×10^{-1}. These exceedances were primarily caused by exposures to disposal and plant area soils, other site soils, groundwater (future use only), and ambient air.

Hazard indices exceeded one for all populations evaluated. The carcinogenic risks associated with exposure to river water, river sediments, pond water, and pond sediments were less than 1×10^{-6} for all populations. The hazard indices associated with exposure to river water, river sediments, pond water, and pond sediments were less than 1.0 for all populations. Based on the exposure assumptions and available toxicity information at that time, the risks to human health associated with surface water and sediments were not significant.

Ecological Risk Assessment
The amended ROD stated that the results of Pre-Design Studies performed subsequent to the 1992 ROD indicated that soils and sediments, which remained on-site did not pose a significant threat to terrestrial and aquatic organisms and that future biological monitoring would also be necessary to verify the protectiveness of benthic organisms and wildlife. Based on studies to date, it could not be definitively stated that the contaminants were having no effect on the environment. No impacts to the environment had been clearly associated with the high levels of contamination in the ecological toxicity studies done to date. In 1995, U.S. EPA's Emergency Response Team conducted an Ecological Risk Assessment focusing on the potential risk of mercury in Tannery Bay. Results showed a low risk to mercury concentrations in the sediments. This study also reconfirmed past studies that indicated there was no direct correlation with chemical concentrations in sediments and levels of toxicity found in test organisms. As a result, a weight of evidence approach was used when determining cleanup levels or remedy necessary for Tannery Bay.

IV. Remedial Actions

Remedy Selection

The initial Record of Decision (ROD) for the entire Site was signed in September 30, 1992. The selected remedy included the excavation and consolidation of waste material, soils, and river sediments, which exceeded specific chemical standards, into an on-site landfill. Collection and treatment of groundwater from construction/dewatering activities; groundwater monitoring; and land use restrictions for landfilled area were other major components of the remedy. Performance standards were described in the 1992 ROD, but additional studies were also required to determine what levels of contaminants in soils and sediments would be protective of surface water and the ecosystem. Estimated costs for this 1992-selected remedy were $14,400,000 (capital costs) and $19, 700,000 (Net present worth). Estimated Operation and Maintenance costs were $458,000 for the first year, $449,000 for years 2-3, $579,000 for year 4, and $303,000 for years 5-30.

On April 12, 1993, the owner of Cannelton Industries, Inc, signed an Administrative Order on Consent (AOC) with U.S. EPA to design the remedy and perform Pre-Design Studies as required by the ROD and Statement of Work for Remedial Design. Pre-Design Studies field work took place from September 1993 through the summer of 1994. A Pre-Design Studies report was completed on October 1994 with U. S. EPA modifications to the document in 1995. An Ecological Risk Assessment was also completed in January 1995, by U.S. EPA's ERT. In 1989 and in 1994 the western Tannery Point shoreline was stabilized with large rock to prevent erosion into the St. Marys River.

Pre-Design and Additional Studies

The Statement of Work (SOW) for the Remedial Design required Pre-Design and Additional Studies to be performed at the Site in order to meet the requirements of the 1992 ROD. The studies were to evaluate: 1) the protection of groundwater and surface water from unacceptable contaminant discharges; 2) direct toxicity of soil and sediment; and 3) bioaccumulation of contaminants. The soil leaching and groundwater studies showed that the quality of groundwater discharging from the Site was protective of the St. Marys River and was expected to remain protective of surface water quality in the future. The results for sediment toxicity and bioaccumulation studies indicated that the sediments did not pose a significant threat to aquatic organisms due to chemical concentrations in soils and sediments in Tannery Bay. The Bioaccumulation Studies performed by HydroQual, Inc. for the site (HydroQual, April 1995), evaluated mercury in terrestrial organisms. Meadow voles were collected and analyzed for mercury body burdens. The body burden data were utilized in a terrestrial food chain model to evaluate mercury food chain threats to target receptors. The results of the terrestrial evaluation of risks indicated that mercury was accumulated by the meadow vole and the accumulation was correlated with the soil mercury concentration. However, the results of the subsequent food chain risk evaluation indicated that there was not a current substantive ecological risk posed by mercury at the site. The risk assessment analysis conducted using the hazard quotient methodology indicated that dietary exposure to metals at the Cannelton Industries Site is generally less than 1-10 percent of the reference dose, with only a few exceptions. In all cases, the hazard quotient was less than 1. The Ecological Risk Assessment conducted by U.S. EPA's ERT (1995) reconfirmed past studies that indicated there was no direct correlation with chemical concentrations in sediments and levels of toxicity found in test organisms. As a result, a weight of evidence approach was used when determining cleanup levels or remedy necessary for Tannery Bay.

ROD Amendment (September 27, 1996)

Based on the results of the Pre-Design Studies, a change in the remedy was proposed by Cannelton Industries in June 1995. At the same time, on June 5, 1995 the State of Michigan passed into law Part 201 of Michigan Natural Resources and Environmental Protection Act (NREPA formerly 641), which changed the environmental clean-up requirements and standards. Part 201 standards are based on different land use scenarios and the potential exposure under each scenario (i.e. residential, commercial, industrial, and recreational). The new regulations allowed for these land use scenarios to be incorporated into the cleanup criteria for the site. A revised proposed plan was developed and presented to the public for input in May 1996. The remedy proposed in the revised plan was more cost effective and addressed the community's land use concerns while still effectively accomplishing the safe cleanup of the Site.

The revised clean up plan took into account the future land use goals of the City of Sault Ste. Marie. The City's Twenty-Year Master Plan has areas within the current site slotted for high-rise residential, recreational along the river and light industrial or commercial. To accommodate these potential future land uses, the zones within the site were evaluated and clean-up levels were selected based on future use utilizing the State's generic clean-up standards.

The ROD Amendment was signed on September 27, 1996 and consisted of:

- Excavation, dewatering, and disposal of tannery waste and soils from the area with the highest contamination concentrations, the Barren Zone (Zone B) in an off-site landfill that meets Resource Conservation and Recovery Act (RCRA) Subtitle D and Part 115 of NREPA solid waste landfill requirements. Excavation and off-site disposal of surficial waste and debris from the western shoreline (Zone A) and of tannery waste from the southern shoreline of Tannery Bay (Zone D);
- Appropriate regrading and landscaping of the western shoreline and backfilling, as necessary, in the Barren Zone area to restore wetland and allow for natural revegetation;
- Construction of surface drainage system and maintenance of shoreline protection to prevent erosion;
- Further evaluation of the sediment in Tannery Bay to assess whether the area is subject to significant erosion. If the evaluation showed a concern for erosion and off-site migration of sediments and site materials, a containment system to prevent off-site migration, or other appropriate measure, would be constructed;
- Further evaluation of site-contaminant stability in soil and sediment to determine the potential for future releases of metals(s) into the environment and to better inform the development of a long-term monitoring program for soils, surface water, and sediments;
- Surface water, groundwater, sediment, wetland soils, and biological monitoring, including bioavailability studies for site-specific metals (chromium, cadmium, mercury, arsenic and lead). A requisite monitoring plan was designed and implemented as part of the amended remedy to monitor the ongoing reduction of groundwater and surface water contamination at the Site, and to determine the stability of soils in the wetland (Zone C), and sediments in Tannery Bay. Biological monitoring was included to verify the protectiveness of benthic organisms and wildlife. The requisite monitoring plan specifies the sampling frequency, parameters, locations, and protocols to be implemented and was to include a contingency[1] for further action if continued reduction of contaminant concentrations were not observed, or if Site conditions indicated that human health and the environment were not being protected. The plan will also be assessed after each sampling event to determine the ongoing Site stability and protectiveness and the need for future modification of the amended remedy or the monitoring plan; and
- Implementation of deed restrictions to limit lands use to industrial, recreational, and residential in certain specific areas of the site.

Estimated costs for this amended remedy were $4,600,000 (capital costs) and with an annual Operation and Maintenance cost of $17,000 the total net present worth is $5,200,000.

Remedy Implementation

The AOC and SOW for Remedial Design was amended on April 15, 1997 to comply with the September 27, 1996 Amended remedy. An evaluation of Tannery Bay sediment stability and an evaluation of contaminant stability in wetland soil were conducted to help develop the long-term Operations and Maintenance Plan and other portions of

[1] This **Contingency Plan** has not been developed thus far. Insufficient data has been collected thus far to evaluate the implemented remedy for Tannery Bay. An evaluation will be made after the third round of Biological Monitoring takes place.

the final remedial design. Design of the remedy was completed on December 30, 1998.

Michigan State University Soil Study-- ***Effect of Environmental Parameters on the Mobility of Chromium in Soils at the Cannelton Industries Site***

The goal of this study was to determine how various environmental parameters influence the fate and transport of chromium and selected heavy metals in surface soils at the Site. Specific objectives were to characterize the spatial variability of chromium and biogeochemical factors that might influence the fate and mobility of chromium in soils at the Site and assess under what conditions chromium could become mobile. These studies were primarily leaching studies.

This report presented the results of a series of studies looking at various manipulations of the soils at the site to determine possible future releases. All of the investigations were limited to releases under anoxic conditions, and did not show what would happen if the soils were disturbed or otherwise aerated. As the report noted, the studies indicated that the noted magnitude of releases would not change if the soils were left as is. However, no data have been presented to indicate the likelihood that future conditions would maintain the present groundwater levels and therefore, maintain the current anoxic conditions.

The studies were consistent in indicating that.the Cr in surface water in both ponded areas and soil porewater, is associated primarily with dissolved organic matter (DOC). Whereas it is reasonable to assume that the Cr in the sediment is behaving similarly, the study did not test this relationship with sediments.

The microcosm studies exposed the soils to both artificial acid rain and nutrient enrichment. In both cases the exposures could be considered short term. In particular, although the effluent pHs were not reported, the text indicates that the experiments were not run to the point that the soil buffering capacity was exhausted. Conceivably, Cr releases would increase substantially if the pH dropped. The investigators also did not determine (or at least report) how much buffering capacity the soils have.

Similarly, four months may not be a long enough exposure to an enriched nutrient system to alter the microbial activities. In addition, no studies appear to have been performed to determine if either of the soil amendments, nitrogen and phosphorus, were limiting nutrients before amendments. It is possible that a micronutrient or vitamin was limiting.

The report notes that releases of Cr were greater in at least some experiments from soils that were unsaturated at parts of the year. These data indicated, as noted above, that aeration of the soils is probably a major factor in enhancing releases. No data have been presented to indicate the likelihood that future conditions would maintain the present groundwater levels. Similarly, the Cr is currently sequestered by organic matter under anoxic conditions, but no consideration was given to the rate at which the organic matter may be metabolized by soil microbes sufficient to alter the binding capacity.

The overall results of these experiments indicated that if the site was maintained in its current state, mobilization of chromium in excess of current concentrations was unlikely. Given the scale of the site and the amount of organic matter in the soils, it is unlikely that either the acid rain effect or the loss of organic matter will be important for the foreseeable future. However, it does appear that maintaining the saturation of the site soils to ensure continued anoxia will be important it keeping the Cr (and other metals) sequestered.

Pre-design Sediment Stability Study—*Stability of Tannery Bay Sediments*, CRA, July 1998

The goal of the sediment stability study was to determine whether sediments at the Site were eroding into St. Marys River or were new sediments depositing over the existing sediments in Tannery Bay. Based on a review of sediment shelf and vegetation growth within Tannery Bay using aerial photography over a 42-year period (1953 to 1995), sedimentation within Tannery Bay is evident. Hydrodynamic and sediment transport modeling further support that Tannery Bay, a shallow bay protected from wave and ice forces by a sediment shelf, is a depositional area for sediments migrating in to the Bay from the St. Marys River with the potential for significant re-suspension of sediments being very low.

Unilateral Administrative Order for Remedial Action

A Unilateral Administrative Order for Remedial Action became effective on February 18, 1998. Cyprus Mines responded to this Order. Cyprus Mines acquired the Site through the purchase of Cyprus-Amax, who was the site owner at that time. Cyprus Mines subsequently submitted the Remedial Action (RA) Work Plan to the U.S. EPA, which described the Remedial Construction (RC) activities necessary to implement the 100% Design. On April 6, 1999, U.S. EPA approved Cyprus Mines' RA Work Plan, which involved the following remedial activities:

1. **Western Shoreline:**
   - excavation and removal of surficial debris and disposal in an off-Site landfill;
   - regrading with clean soil and landscaping of the area as appropriate for future land use; and
   - construction of surface drainage works to prevent erosion.
2. **Barren Zone:**
   - excavation and removal of the sprinkler system and soil and tannery waste down to clean sand;
   - dewatering of excavated materials and disposal in an off-Site landfill; and
   - minimal backfilling, as necessary, of the excavated area with clean fill to maintain a stable shoreline and prevent erosion.
3. **Tannery Bay/Sediments:**
   - removal of visible surficial waste along the southern shoreline of Tannery Bay where waste is not adequately covered or contained in order to minimize erosion and disposal in an off-Site landfill; and
   - shoreline stabilization along the southern shoreline.
4. **Plant Area:**
   - removal of stockpiled soils on concrete slab; and
   - monitoring well abandonment throughout the Site.

The remaining components of the RA Work Plan provided for deed restrictions and monitoring of the remedy.

After a detailed evaluation of available landfills for disposal of the materials, Waste Management Inc.'s (WMI's) Waters landfill located approximately 120 miles south of the Site, and Dafter landfill, located 12 miles south of the Site, were selected as the preferred landfills for material disposal. On-Site soils were characterized and confirmed to be non-hazardous and well below the landfill's acceptance criteria for disposal.

Envirocon, Inc. of Missoula, Montana, a contracting firm selected by the competitive bid process, performed the RA activities at the Site. The contractor had performed similar types of heavy construction activities in the past, and was well equipped to undertake this project.

On June 8, 1999, Envirocon mobilized to the Site and a kick-off meeting was held at the Site to review the Site activities. Details of Envirocon's completed construction activities are as follows:

- Removal of the ground level fire protection sprinkler system located in the Barren Zone concurrent with the clearing and fence removal operations;
- Removal and off-Site disposal of approximately 306 tons of surficial waste/residually-impacted soils and debris from the Western Shoreline. Surficial debris consisted of scrap metals, wood, glass, empty metal drums, building materials, unfinished leather, a snowmobile, concrete pieces, and the like. The shoreline was then graded to a maximum 4 to 1 (horizontal and vertical) slope in accordance with the specifications and common

fill was placed and compacted to a depth of 6 inches. Disturbed areas were covered with topsoil and seeded on October 14, 1999 to enhance the western shoreline's restoration;

- Excavation, removal, and off-Site disposal of approximately 31,528 tons of affected soils from the Barren Zone from July 20 to September 14, 1999. Confirmatory soil sampling was conducted in accordance with MDEQ sampling protocols. All transfer, loading, and off-Site disposal of stockpiled soils to the selected landfills was completed utilizing haul trucks. All haul trucks were equipped with a lead and trailer (pup) to minimize the number of trips required for soils disposal. Soils were transported off-Site using licensed waste haulers. All truck lead and pup boxes were lined with 6-mil construction grade polyethylene plastic prior to loading to provide for leak protection and prevent soils from being wind blown. Soils also were covered with canopy covers on both leads and pups to further prevent soils from being wind blown. Common fill material was placed and compacted using the existing dozers and wheel tired loaders and haul trucks to achieve the specified compaction. Grades along the west and east limits were matched with slopes along the Barren Zone to a 10 to 1 slope (horizontal to vertical);
- On August 30, 1999, Envirocon then commenced remediation of the southern Tannery Bay shoreline. Approximately 159 tons of tannery-related wastes were removed and disposed of off Site. Following shoreline remediation, the southern shore of Tannery Bay was stabilized with a geo-membrane overlain by large rock;
- To ensure that all excavated soils were properly dewatered and that the water was treated to within State standards a water treatment system was installed and the treatment plant discharge was directed to the two Frac tanks for holding until receipt and acceptance of the initial analytical results for the discharge. Analytical results of the composite treated water were sampled and when the sample met the SRD permitted discharge concentrations for both hexavalent chromium and total mercury analyses the water was discharged directly to the St. Mary's River, as per the SRD. In total, approximately 3.2 million gallons of excavation and rainwater were treated through Envirocon's water treatment system throughout the remedial construction activities;
- From July 26 to 28, 1999, Envirocon abandoned 55 monitoring wells previously installed, as part of the Remedial Investigation at the Site;
- On September 30, 1999, following the placement and compaction of common fill in the proposed locations, Envirocon proceeded to install three shallow monitoring wells (MW-101, 102, and 103) within the Barren Zone as part of the long-term monitoring requirement for the Site. All three monitoring wells were advanced to a depth of 15 feet bgs utilizing a 5-foot screen in each well; and
- As of project completion, a total of 31,992.76 tons of soils and surficial waste had been disposed of off Site to WMI's Dafter and Waters landfills, of which approximately 18,543.15 tons were disposed of at the Dafter landfill, and the remaining 13,449.61 tons were disposed of at the Waters landfill.
- Shoreline stabilization/berm restoration was completed by restoring approximately 700 feet of berm along the entire length of the former barren zone following the excavation, soil verification sampling, and backfilling activities. Also, 600 feet of shoreline protection berm was constructed along the southern shore of Tannery Bay, following the removal of shoreline waste and debris.

Site personnel and local residents were protected throughout the RA activities from Site hazards and airborne contaminants through the implementation of the health and safety plan and a perimeter air monitoring program.

On September 24, 1999, representatives from USEPA, MDEQ, Cyprus, CRA, and Envirocon conducted the Pre-Final Construction Inspection for the Site. All construction activities had been completed as required and the only remaining activities at the site were seeding and minor final activities. USEPA completed the Preliminary Close Out Report (PCOR) on September 27, 1999. The remaining activities were completed at the Site in October 1999, and the USEPA Final Inspection was conducted on October 19, 1999.

Details of the remedial construction activities were presented in a Construction Completion Report dated December 1999, and approved by the USEPA in 2000. Photos of the Site, as it currently exists (taken during Site Inspection, June 2004) are attached as **Appendix B**.

Long-Term Operation and Maintenance (O&M)

The Operation and Maintenance Plan (O & M Plan) provides general information and details the inspection requirements and ongoing monitoring programs at the Site. The monitoring programs include groundwater and surface water monitoring, physical and biological monitoring within Tannery Bay, and wetland monitoring. USEPA approved the November 1999 O & M Plan on May 5, 2000, with modifications. The plan was revised and the Final O & M Plan was submitted by CRA on behalf of Cyprus Mines Corporation, to the USEPA on June 13, 2000.

The O&M requirements at the Site are as follows:

1. Inspection and maintenance of the protected shoreline to ensure long-term integrity;
2. Post-construction groundwater and surface water monitoring;
3. Post-construction Tannery Bay monitoring, including surface water, sediment, and biological monitoring to assess potential changes in the bioavailability of site-related contaminants over time;
4. Post-construction wetland monitoring.

Since completion of the 1999 Remedial Action, three monitoring events have been conducted to date (June and November 2000, and December 2003) along with one biomonitoring event (2000). Results of these monitoring events are presented in the following sections:

1. Protected Shoreline

Inspection activities were completed to document the integrity and stability of the shoreline protection, bluff slopes, and fences remaining after the remedial action. The western shoreline, southern shoreline of Tannery Bay, and shoreline along the former Barren Zone are inspected to ensure stability and integrity. Bluff slopes, vegetation, and remaining fences are also inspected. Monitoring events have shown no concerns within the Site as the shoreline protection remains intact and Site slopes are all vegetated.

2. Groundwater and Surface Water

Long-term chemical-specific monitoring for surface water and groundwater has been conducted after remedial activities to verify that the remedy has performed its primary function of removing contaminated soils and reducing migration of compounds to the environment. On May 9, 2001, the 2000 Fall Sampling Event Operation and Maintenance Report was submitted to the USEPA. Results from the initial two semi-annual monitoring events showed no concentrations of chemicals of concern in groundwater. As a result, the May 2001 report contained recommendations for reduction in surface water and groundwater monitoring at the Site. In a July 31, 2001 letter to Cyprus Mines, the USEPA approved a reduction of the frequency of groundwater and surface water monitoring.

The 3rd round of groundwater and surface water sampling was conducted in December 2003. Surface water sampling was conducted along with groundwater due to a postponement of the summer of 2003 biological monitoring event. The groundwater and surface water samples analyses included low-level mercury analysis as requested by MDEQ during the development of the O&M Plan. This method was not available in previous sampling events. Results from the December 2003 semi-annual monitoring events are detailed as follows:

<u>Groundwater Monitoring</u>

Groundwater samples were collected in accordance with the sampling protocols presented in the OMP and the QAPP Amendment. Groundwater samples were collected from all eight downgradient monitoring wells (MWs 04, 47, 101, 102, 103, 93-01, 93-02, and 93-03) and three of the four upgradient monitoring wells (MWs 32, 02S, and 12) and analyzed for low level mercury. Monitoring well locations are shown on Figure 4. Sampling activities included the collection of two duplicate samples, one MS/MSD, and one field blank. Groundwater quality measurements of pH, conductivity, temperature, dissolved oxygen, and ORP were collected.

Review of the analytical results, for the December 2003 sampling event indicates that mercury was not detected throughout the Site, with the exception of upgradient monitoring wells MW-02S and MW-32, which had concentrations of 0.0041 and 0.00054 μg/L respectively, and one downgradient monitoring well MW-04 with a concentration of 0.00066 μg/L. All detected mercury concentrations were well below the mercury performance criteria of 2 μg/L for groundwater at the Site.

In summary, reported groundwater concentrations for the fall (December 2003) sampling event are either the same or lower compared to the previous two (June and November 2000) sampling events. The groundwater quality measured at the Site meets the performance criteria identified in the OMP. Table 1 shows Summary of Groundwater Data for the first 5 years of monitoring.

<u>Surface Water Monitoring</u>

Fourteen surface water samples were collected in accordance with the sampling protocols presented in the OMP and the QAPP. Surface water samples were collected from twelve surface water locations and analyzed for arsenic, cadmium, chromium III, chromium VI, lead, and low level mercury, as well as total organic carbon and hardness. Surface water samples were collected from the following locations (See Figure 5):

- four upstream samples;
- three samples along the main shoreline of the Site;
- four samples in Tannery Bay; and
- one sample from a pond on Site.

Surface water samples SW-1, 2, 5, 6, and 7 were modified, as necessary during the December 2003 sampling event, relative to the previous (Spring and Fall 2000) sampling programs due to thick ice cover along the shore and within Tannery Bay at the time of sampling. Surface water samples SW-8 and 10 within Tannery Bay required ice cutting for sample collection. Due to the ice conditions within Long Pond, surface water sample SW12 was collected using waders, which may have disturbed the standing water and corresponding sediments. Sampling activities included the collection of one field blank for low-level mercury analysis and two duplicate samples. Water quality measurements (pH, conductivity, turbidity, and temperature) were recorded at each location.

Review of the analytical results indicates no detection of the parameters arsenic or chromium (VI) in the surface water. Cadmium was detected at the Seymour Creek discharge location (upstream of the Site) (SW-2) at a concentration of 0.37 μg/L and at Long Pond (SW-12) at a concentration of 0.66 μg/L, relative to the performance criterion of 0.37 μg/L. Chromium III was detected within Tannery Bay (SW-9) and Long Pond (SW-12) at concentrations of 63 and 100 μg/L, respectively, both above the performance criterion of 43.6 μg/L. Lead was detected at Long Pond (SW-12) at a concentration of 3.5 μg/L, which is marginally above the performance criterion of 3 μg/L. Mercury was detected at concentrations ranging from 0.00098 to 0.0081 μg/L in eleven of the surface water samples. Four samples (SW-1, 2, 9, and 12) showed mercury concentrations above the performance criterion of 0.0013 μg/L. Two of the detected mercury concentrations, which exceeded that performance criterion, were collected at upstream locations, namely Izaak Walton Bay (SW-1) and Seymour Creek (SW-2) at concentrations of 0.0016 and 0.0059 μg/L, respectively. The three samples collected from along the site shoreline had mercury concentrations below the performance criterion. One sample of four from Tannery Bay (SW-9) had a detected mercury concentration of 0.0073 µg/L. The sample collected within Long Pond at (SW-12) had a mercury concentration of 0.0081 µg/L.

The presence of cadmium, chromium III, lead, and mercury at SW-12 within Long Pond, are likely a result of disturbance of the sediments due to sample collection technique, which required the use of waders. Due to the ice cover on the pond, it was not possible to collect a sample from the shore during this monitoring event. Levels of chromium III and mercury detected within Tannery Bay at SW-9 both exceeded their respective performance criteria. Based on a preliminary statistical evaluation, which allows a mean plus three standard deviations for comparison to background, the low-level mercury concentration of 0.0073 µg/L at SW-9 is not above background (upstream) levels. Elevated concentrations of chromium III may reflect floating particulate matter observed at this sample location flowing into the Bay.

In summary, the surface water quality measured at the Site was above the performance criteria identified in the OMP at two upgradient locations on the St. Mary's River (SW-1 and 2), one downstream location within Tannery Bay (SW-9), and within Long Pond (SW-12). With the exception of the sample collected at Long Pond, the levels of analyzed parameters from across the Site are generally the same or lower compared to the previous sampling events. A statistical comparison of the data indicates the detection of mercury within Tannery Bay is not above background (upstream) concentrations.

A summary of the analytical data from all three monitoring events, which were conducted in the first 5 years of post-construction monitoring, are shown in Table 2.

3. Tannery Bay Biological and Sediment Monitoring

The purpose of the Tannery Bay monitoring program is to provide data regarding the fate and environmental impact, if any, related to the presence of elevated metal concentrations in Tannery Bay sediments. Monitoring would provide a measure of any trends that may indicate that the Tannery Bay sediments are migrating out of the Bay at significant concentrations, or that the sediments are an environmental concern. Monitoring includes an assessment of the bioavailability of chromium, lead, cadmium, arsenic, and mercury in Tannery Bay sediments and an evaluation of the stability of sediments in Tannery Bay.

<u>Biological Monitoring in Tannery Bay</u>
The purpose of the biomonitoring program is to verify whether the selected remedy for the site is effective at reducing concentrations of bioavailable trace elements in Tannery Bay. Specifically, the objectives of the biomonitoring program are to determine 1) whether chromium, total mercury, methylmercury, lead, cadmium, and arsenic in Tannery Bay sediments are available to aquatic biota residing in and/or using the Bay, and 2) whether exposure to bioavailable concentrations of metals may adversely affect local biota. The biomonitoring program has three components: 1) evaluation of bivalves transplanted to the study area for trace element uptake and growth, 2) analysis of sediments for concentrations of metals and selected physiochemical parameters, and 3) analysis of surface water for concentrations of trace elements, selected physiochemical parameters, and chlorophyll-*a*.

The monitoring program anticipates a minimum of three bivalve monitoring events. To date two bivalve monitoring events have been completed, a baseline event and one post-construction-completion event. The second round of post-construction biological monitoring was scheduled for 2003; however, due to difficulties obtaining test organisms in 2003 and low water levels in 2004, the event is planned for summer 2005. The tissue chemistry data from post-construction events will then be statistically analyzed and compared to baseline values to determine if there is a discernable trend in metals accumulation. This trend analysis will then facilitate an evaluation of the effectiveness of the remedy in protecting benthic organisms and wildlife inhabiting Tannery Bay and utilizing river areas adjacent to the Cannelton Industries site. The need for modifications to the biomonitoring program will be assessed at that time.

NOAA conducted a baseline clam monitoring study for U.S. EPA in the summer of 1997. To assess bioavailability, uptake of the contaminants of concern was measured in tissues of caged clams, *Corbicula fluminea,* transplanted to Tannery Bay and reference areas providing a baseline data set. The clams were transplanted to Tannery Bay and reference areas from July to September 1997 (NOAA and EVS 1998). Survival and changes in bivalve whole-animal wet weights and end-of-test tissue weights were evaluated to assess the health of the transplanted clams and to facilitate net contaminant uptake calculations. Clams at all stations in Tannery Bay accumulated chromium and lead. Clams at one or more Tannery Bay stations accumulated cadmium and arsenic. Mercury uptake by clams could not be assessed due to high initial concentrations. Sediment concentrations of chromium, arsenic, cadmium, lead, and mercury were elevated compared to concentrations at reference stations. Sediment chromium had a maximum concentration of 20,598 ppm dry wt. The complete report can be found at http://response.restoration.noaa.gov/cpr/library/publications.html or in the site files.

The first round of post-construction biological monitoring was conducted by HydroQual Inc. and Applied Biomonitoring on behalf of Cyrpus Mines Corp. from July to September 2000 using a different source of *Corbicula* (Phelps Dodge 2002). Clams at all stations in Tannery Bay accumulated chromium, cadmium, lead, and arsenic. Methylmercury was depurated by clams at most Tannery Bay stations compared to initial concentrations, but was higher than concentrations in clams from reference stations. Sediment concentrations of chromium, arsenic, cadmium, lead, and mercury were elevated compared to concentrations at reference stations. Sediment chromium had a maximum concentration of 30,000 ppm dry wt. The complete report can be found in the site files.

Sediment Monitoring

In association with the biomonitoring program, sediment in Tannery Bay has been monitored for trace element concentrations, total organic carbon, and grain size. A comparison of maximum detected concentrations of contaminants of concern in Tannery Bay over time indicates the anisotropic nature of the contamination. **Table 4** indicates that trace element concentrations in sediments appear to have remained stable over time.

Table 4: Maximum Concentrations of COCs Measured in Sediments of Tannery Bay

	Sediments Historical ppm	Sediments 1997 ppm	Sediments 2000 ppm
Arsenic	29.6	23.8	17.2
Cadmium	26.1	14.1	65.6
Chromium	40,000	20,598	30,000
Lead	603	218	350
Mercury	2.3	2.07	2.44

The amended remedy did not anticipate a direct reduction in bulk sediment contaminant concentrations, rather the remedy anticipates a reduction in the bioavailability of these contaminants over time due to the expected natural sedimentation of Tannery Bay and the resultant encroachment of the wetlands over the contaminated sediments, similar to the historical wetland growth on Tannery Point. As discussed above in the Pre-design Sediment Stability Study Section, a review of historical aerial photographs in that study indicated that the contaminated sediment in the western portion of Tannery Bay is being capped through natural sedimentation and vegetation encroachment. In order to verify whether these observed trends are continuing, EPA obtained high-resolution imagery through the U.S. ACE and requested assistance from NOAA in analyzing this new data. This imagery analysis is reported under the Data Review Section below.

4. Wetland Monitoring

Long-term stability of soils in the wetland area was evaluated by MSU and the results of these studies were used to confirm a monitoring plan for the wetland area. Previous soil and groundwater data collected in the wetland area demonstrated that conditions in the wetland are protective of human health and the environment. The results of the MSU soil leaching study, which assessed potential future COC releases to surface water, concluded that, provided that existing conditions are maintained, the mobility of chromium should not change. Therefore monitoring in the wetland would consist of visual inspection and review of aerial photographs. As required in the ROD Amendment, the wetland area is subject to institutional controls and wetland protection requirements to restrict the use of these wetlands. The property owner has not yet implemented the institutional controls since discussions are taking place with the City of Sault Ste. Marie for property transfer to the City of Sault Ste. Marie. Once these controls are in place, monitoring will be completed to enforce the institutional controls. Currently, wetland area remains fenced to prevent any trespassing or vandalism. The fence is considered an appropriate measure at this time. Also, as described in the Surface Water Section above, surface water samples were collected from the wetland ponds to ensure that water quality remains protective of human health and the environment. Surface water in the wetland ponds will continue to be sampled as in the past five years.

Table 5 shows cost figures provided by the PRP, Cyprus Mines Corporation, whom is responsible for conducting the O&M at the Site.

Table 5: Annual System Operations/O&M Costs

Dates		Total Cost rounded to nearest $1,000
From	To	
January 2000	December 2000	$400,000 (2 semi-annual and 1 biomonitoring)
January 2001	December 2003	$30,000

Current Status

The selected remedy has been implemented as required in the 1997 ROD Amendment. After two monitoring events, EPA completed an Interim Remedial Action (RA) Report on July 23, 2002, which documents actions completed to meet requirements per the ROD Amendment. This Interim RA Report can be found in files for the Site.

Zones A, B and E

In 2002, EPA drafted a Notice of Intent to Delete portions of the Site from the NPL. Zones A, B, and E have met all clean-up goals and these areas meet delisting criteria. The deletion process began in March 2002 with the development of a draft package submitted to MDEQ for concurrence. However, concurrence has been delayed pending a response from the PRP (owner of the site) with their assertion that the site meets MDEQ land use closure criteria and related administrative requirements for closure. EPA is satisfied that clean-up standards have been met for zones A, B, and E, and proposed these areas for partial delisting of the NPL in 2003. However, NPL delisting requires state concurrence and a response to MDEQ's request for additional information, is needed in order to concur with NPL delisting of these areas. These zones are ready for reuse and redevelopment. The site is currently zoned for industrial use, but residential standards were achieved in Zone A, recreational in B, and a mix of residential/industrial standards are present in zone E.

Reuse and Redevelopment

Since the completion of remedial activities, the City expressed an interest in utilizing portions of the site for their City's Public Works Building. The City, Cyprus Mines Corporation, EPA, and MDEQ began discussions regarding the reuse potential and the necessary steps needed to accomplish end use goals. These steps include partial NPL delisting of zones A, B, and E, a more detailed delineation of property owned by Cyprus Mines Corporation, with the areas that have met clean up standards, and a legal agreement for property transfer to the City of Sault St. Marie, Michigan. Discussions between the City and Cyprus Mines Corporation have taken place and a draft agreement regarding property transfer has been developed. Discussions will continue, to achieve the redevelopment goals for the site.

Zones C and D (Tannery Bay and Wetlands)

As discussed above in the Tannery Bay Biological and Sediment Monitoring Section, biological monitoring is taking place as required in the ROD Amendment. The second post-remediation event was planned for the summer of 2004. However, during the site inspection and field reconnaissance of June 8, 2004, EPA and NOAA noted that implementation of this biological monitoring event would be problematic due to the low water conditions, which would likely preclude the collection of valid exposure data in the west and southwest portions of the bay where historic sediment contamination is highest. Based on current conditions, the biological monitoring event was postponed until next summer (2005).

V. Progress Since the Last Review

This is the first review for the Site.

VI. Five-Year Review Process

Administrative Components

The five-year review process began in July 2002 when, Cyprus Mines Corporation and its consultants were notified that a five-year review would be performed for this Site. In a meeting, the general five-year review process was discussed. A proposed schedule was developed and Review Team was identified. The review team included Rosita Clarke-Moreno, U.S. EPA Project Manager, Todd Goeks from NOAA, Patrick E. Lee, EMC^2, Dan Johnson, Cyprus Mines Corporation, and Bruce Van Otteren , MDEQ.

Cyprus Mines Corporation wrote an initial letter dated December 16, 2002 to U.S. EPA proposing their level of involvement. A Conference call was held on February 27, 2003 to further discuss five-year review process and Team responsibilities.

EPA also requested technical support via an IAG with NOAA for the five-year review and for technical assistance with the biological monitoring program. The U.S. ACE obtained aerial ortho-photography of the site thru an Inter-Agency agreement with U.S. EPA.

Community Notification and Involvement

EPA notified the community that a five-year review was required at the site and what the process would be via a Fact Sheet and Press Release in October 2002. An availability meeting was held on October 23, 2002 and a notice was also made in the Evening News, the local newspaper on October 25, 2002. Participants at the meeting expressed their concerns for monitoring at the Site and some expressed concerns for the remaining sediments. Questions regarding the partial delisting and reuse in general were also answered at this meeting.

On May 12, 2004, EPA communicated with representatives of federally-recognized tribal governments and inter-tribal consortia located in the area via email expressing an interest to meet with them to discuss site status, five year review process and receiving input from them regarding the overall remedy at the site.

On May 26, 2004, a letter with status of site activities and upcoming Five Year Review was mailed to the community.

A meeting with representatives of federally-recognized tribal governments and inter-tribal consortia located in the area was held on June 8, 2004. (See Interviews below)

On June 8, 2004, EPA RPM met with the City Manager of Sault Ste. Marie, Mr. Spencer Nebel. Other participants in this meeting were, Bruce Van Otteren, and Daria Deventier of MDEQ, and Daniel Johnson of Phelps Dodge.

Document Review

Documents reviewed for this five year review include the ROD, ROD Amendment, Remedial Action and Construction Completion Report, O&M Plan, Monitoring and Bio-Monitoring reports, as well as other documents for the site. A complete list of documents reviewed, is found in **Appendix A.**

During this five-year review process, EPA reviewed all investigation reports and decision documents for the Cannelton site. Remedial Investigation and Pre-Design documents were important in evaluating the site pre-construction conditions of the Site. The ROD and ROD Amendment were reviewed to ensure that all requirements have been met and implemented during remediation activities. Remedial Action and construction completion reports were reviewed for actions implemented at the site. O&M reports provided overall data and information collected in the last five years.

Data Review

Historical data for the site was reviewed along with post-construction data collected during the Operation & Maintenance phase. Sediment, biological monitoring, surface water, and groundwater data were evaluated based on the monitoring reports submitted by CRA on behalf of the Respondent (Cyprus Mines), which were reviewed and accepted by EPA.

A review of monitoring data is found on page 24-25 in the Long-Term Maintenance section. Surface water and ground water data and sampling locations are summarized in Tables 1,2, and Figures 4 and 5.

Imagery Analysis of Change in Extent of Wetlands Encroachment on Tannery Bay and Bay Sedimentation Trends

As part of the Five-year review, EPA and NOAA acquired high-resolution ortho-rectified aerial imagery flown in 2003 through contract with the U.S. ACE to support an analysis of changes in sedimentation and vegetation in Tannery Bay. NOAA evaluated the change in sedimentation and the encroachment of vegetation into Tannery Bay over the last 19 years by comparing 1984 U.S.ACE imagery of the St. Mary's River region against the 2003 imagery. Both sets of imagery are projected in UTM zone 16 NAD 83. The 2003 imagery is very accurate and has higher resolution (6" pixel). The 1984 imagery has a pixel resolution of 0.5 meters. In conducting the analyses, NOAA discovered that certain areas of the 1984 imagery appeared to have some rectification-derived distortion, which is most significant in the southeast portion of the image. This distortion represents an approximate 5-meter offset.

NOAA's evaluation was conducted in ArcView ® by using the imagery as base layers for each year evaluated and creating shape files to compare the changes in both sediment and vegetation extent over time. The extent of the sediment and vegetative cover features was qualitatively determined using site knowledge developed over 8 years of fieldwork to guide the direct analysis of the imagery. The overall areas of these features were calculated for each analysis year. The changes in the Tannery Bay features were then compared to calculate the magnitude of the respective changes over time. Table 6 lists the features that were used to evaluate changes over time.

Table 6. Habitat Types

Type	Description	General Definition
Water	Shallow Bay	Shallow portion of Tannery Bay due to sediment accretion--generally, less than 2 feet deep
Water	Deep Bay	Deeper area within Tannery Bay, less noticeable sediment accretion
Water	Wetland Ponds	Ponds and water saturated areas inland from the main bay
Vegetation	Shore	Shore and inland to road, vegetation extent and all land surface areas, excluding ponds and bay.
Vegetation	Islands	Emerging vegetation in bay, cattail islands
Hard Surface	Unvegetated Shore	Non-vegetated, non-water, undetermined shore or riprap

The analysis of bay sedimentation focuses on the eastern and northern portions of Tannery Bay. Figure 6 shows the extent of the bay sediment in 1984 compared to the extent of the sediment in 2003. The channel along the eastern shore of Tannery Bay, evident on the 1984 image, was approximately six to eight feet deep and led to a large deeper depression or "bowl" in the southeastern portion of the bay. Sediment deposition in the bay had filled in the channel by 2003 and the bowl had become much shallower. During the site inspection, conducted June 8, 2004, the entire former channel area appeared to be less than two feet deep. The southeastern portion of the bay was also noticeably shallower with the bowl having no clear demarcation as is evident on the 1984 image. The features used for the comparative analysis are shown on Figure 7. The teardrop shaped polygon depicting the depression on the 2003 image was intentionally left in a rough vector shape as opposed to the smoothed polygon developed for the 1984 image as the boundaries of the depression were no longer clearly decipherable. Figure 8 shows the 1984 and the 2003 imagery with vector overlays depicting the extent of the sediment features for the opposite year. Over the time period depicted, approximately 6.4 acres of deep bay transitioned to shallow bay due to sedimentation. The analysis of change in sediment extent revealed however, that only an additional 4.7 acres of shallow bay were present in 2003 as compared with 1984 (Table 7).

Table 7. Tannery Bay Sedimentation

TYPE	1984 AREA (acres)	2003 AREA (acres)	CHANGE 1984 to 2003 (acres)
Shallow Bay	26.4	31.0	**4.7**
Deep Bay	14.2	7.9	**-6.4**
Total Bay	**40.6**	**38.9**	**-1.7**

The difference and apparent loss of 1.7 acres of bay is explained by looking at the encroachment of vegetation into the bay during the analysis period (Table 8). Figure 9 shows the 1984 and the 2003 imagery with vector overlays depicting the extent of the vegetation features for the opposite year. The expansion of the cattail wetland along the western and southwestern shores of Tannery Bay, contributed an additional 1.3 acres of wetland to the bay. The cattail islands also expanded in 2003, increasing by approximately 0.4 acres during the past 19 years.

Table 8. Vegetation Encroachment on Tannery Bay

TYPE	1984 AREA (acres)	2003 AREA (acres)	CHANGE 1984 to 2003 (acres)
Islands	0.9	1.3	**0.4**
Shore encroachment	22.2	23.5	**1.3**
Total Bay Encroachment	**23.1**	**24.8**	**1.7**

While the wetland encroachment along the west shore of Tannery Bay is a direct result of the growth of both the mainland cattail wetland and the growth of the cattail islands, the shoreline encroachment in the southwestern corner of Tannery Bay has been influenced by the addition of a large beaver dam as well as the direct growth of the wetlands (Figure 10). Looking at the overall site, an analysis of the combined surface water area for Tannery Bay and the wetlands ponds reflects an overall loss of 0.8 acres of surface water area (Table 9). Increased beaver activity, as indicated by the dams depicted on the 2003 imagery, appears to be the main factor in the 0.9-acre increase in the wetlands ponds area over the analysis period.

Table 9. Change in Site-wide Water Area

Type	1984 AREA (acres)	2003 AREA (acres)	[illegible]
Bay	40.6	38.9	**-1.7**
Wetland Ponds	0.4	1.3	**0.9**
Total Water	**41.0**	**40.2**	**-0.8**

The findings of this imagery analysis support the supposition in the Amended ROD that Tannery Bay is a net depositional area for sediment and the wetlands of Tannery Point are encroaching on the bay. This is reflected most dramatically by the transformation of 6.4 acres of deep bay to shallow bay, which includes the complete sedimentation of the former channel along the east shore of Tannery Bay, and the 1.7-acre wetland encroachment into the bay along the western and southwestern shores. As noted above, the entire are of the depression in the southeastern portion of Tannery bay was also noticeably shallower during the 2003 site inspection. In 1984, the channel between the large cattail island and the cattail wetland along Tannery Point was 19 meters wide. By 2003, wetland growth had decreased the channel width down to 2 meters. The analysis conclusively shows that Tannery Bay is becoming shallower due to sediment deposition and decreasing in size due to wetland encroachment. While the assumptions of Tannery Bay being a net depositional area and the wetlands encroaching on the bay over the areas of contaminated sediment appear to be correct from this imagery analysis, additional questions regarding the effectiveness of the observed sedimentation and wetland encroachment on the anticipated decrease in bioavailability of site-COCs need to be addressed. As discussed above in the Tannery Bay Biological and Sediment Monitoring Section, the biological monitoring evaluation, when completed during the next 5-year review, will verify whether the increase in observed sedimentation and wetland encroachment translate into decreased bioavailability of site related COCs. Another question, concerning the potential trace element çycling by the cattails that are growing over the contaminated sediments is addressed in the next sub-section.

Metals Cycling by Wetland Vegetation
Concerns have been raised regarding the potential for wetland vegetation overlying contamination to cycle metals from subsurface to surface sediment and soil, and to cycle metals into the food chain at the site. NOAA conducted a review of the available literature to address this concern for the 5-yr review.

Metals can be taken up by cattails *Typha* species directly from sediment, porewater, surface water, and air. Roots tend to have the greatest concentration followed by rhizomes, then, shoots and leaves, respectively. While roots do extract a significant metal fraction, the relatively smaller biomass of the roots, versus the leaves, limits the potential for metal redistribution via leaf senescence or animal dissemination. The full literature review is included in **Appendix E**.

Site Inspection

A visual inspection of the bay, shoreline, and the land portions of the site took place on June 8, 2004. Participants at this meeting were Remedial Project Manager for U.S. EPA, Rosita Clarke-Moreno, Bruce Van Otteren, MDEQ State Project Manager; Daria Deventier, MDEQ, Daniel Johnson, Cyprus Mines Corporation; Mike Ripley, Paul Ripple, Dwight Sargent; Jane Neuman, EPA; Jennifer Manville, EPA, Michigan Tribal Liaison. NOAA, HydroQual, and CRA conducted a physical inspection of Tannery Bay sediment conditions and reconnaissance for the biological monitoring program.

The Tannery Bay inspection commenced at 8:15 am. Water depths throughout the bay appeared consistently shallower as compared with depths from the 1997 baseline biological monitoring event. This was most noticeable along the eastern shore of the bay, where a previous six to eight foot channel is now approximately two feet deep or shallower. Due to low lake levels, the water depths along the western and southwestern wetland shore varied from zero to approximately eight inches. Water depth fluctuations in this corner of the bay are common due to wind-driven waves and commercial ship traffic.

The inspection for the upland portions of the site began at 10:30 am. A walk through the site was made and observations noted regarding vegetation, general site and fence conditions. The physical condition of the shoreline was inspected and found to be in good condition. Vegetation throughout the former "barren" area is growing well. There are no treatment or containment systems at the site; therefore, inspection focused on the condition of site property, shoreline, and existing fences along the site. The lock to the fence in the former plant area "E" was missing and gate was open. The lock for this gate was replaced by Cyprus Mines Corporation on June 9, 2004, following the site visit.

Interviews

Interviews were performed with the City Manager and representatives of federally-recognized tribal governments and inter-tribal consortia located in the area. The purpose of these formal and informal interviews was to obtain feedback and input from the community regarding their view of site clean-up and progress.

A meeting with Tribal representatives was held on June 8, 2004. Tribal representatives included Paul Ripple from Bay Mills Indian Community, Dwight Sargent, ITC of MI Inc., and, Mike Ripley from Chippewa-Ottawa Resource Authority. EPA personnel at this meeting included Rosita Clarke-Moreno, RPM for the Site, Jennifer Manville, Tribal Liaison and Jane Neumann, Superfund Tribal Coordinator. At this meeting, concerns were expressed for the remaining sediments on site and potential concerns for any health effects from fishing and eating fish around the site.

Another concern was the future use of the site. The tribal representatives would like to see the area reserved for natural recreational areas, such as bike or walk pathway. A concern for the future use of the Bay area if sediments are removed through the Great Lakes Legacy Act was also expressed.

A meeting with the City Manager was also held on June 8, 2004. Mr. Spencer Nebel, City Manager of Sault Ste. Marie expressed his concerns for the delay in the partial delisting process and potential reuse of the Site. The delisting process has been delayed and the City's plans for redevelopment have also been delayed due to this. The City Manager would like to see the process move along faster. EPA also presented to the City Manager a new EPA initiative for Redevelopment and Reuse called "Tear down the Wall Initiative." The goal of this initiative is to assist communities with a Superfund site to overcome obstacles in achieving the end goals of redevelopment. The City and the property owner have shown an interest in redevelopment, and participating in this new initiative will aid in the process.

VII. Technical Assessment

Question A: **Is the remedy functioning as intended by the decision documents?** YES. The remedy implemented is functioning as intended based on the ROD Amendment. Excavation of contaminated soils and tannery materials from the Barren Zone (Zone B) has eliminated the direct contact exposure. Surface water continues to be sampled along with sediments to evaluate the decrease in metal concentrations. Groundwater was not affected from contamination or from excavation activities. The remedy for Tannery Bay was based on the rates of sedimentation in the bay area. The results of the Sediment Stability study and the imagery analysis included in this report show that sedimentation is taking place and a natural wetland is covering the contaminated sediments. Performance standards for groundwater have been met and surface water concentrations continue to improve, but there are still some locations within Tannery Bay with exceedances. Additional monitoring data is needed to make an appropriate determination regarding the long-term protectiveness of the sediments at the Site.

Since soils were cleaned up to meet specific land use requirements, parcels meet standards for residential, industrial and recreational use. Currently all the property is zoned for industrial use. However, the City's 20-year Master Plan for future use, lists certain areas within the property for residential use. Since completion of remediation activities, the City of Sault Ste. Marie began discussions with property owner to potentially acquire the property. To aid in the process, U.S. EPA proposed that the parcels (A, B and E) could be delisted from the NPL. Partial delisting will be completed once the MDEQ requirements are met.

Specific institutional controls (I.C.) in the manner of Deed Restrictions have not yet been integrated due to the discussions regarding potential transfer of property to the City of Sault Ste. Marie. Other methods of I.C.s are in place however, such as the City's current zoning (industrial use) and fence surrounding the former plant area and along South Street on the site. The fence along South Street remains to prevent trespassing only and was not required as part of the remedy. There are currently no concerns with soils at the site. Warning signs were eliminated as a request from the City when remediation was completed.

Question B: **Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of remedy selection still valid?** YES. The Remedial Action Objectives in the ROD Amendment are still valid. Remediation goals were based on Michigan's Part 201 standards for future use. The site was divided in parcels to better define the areas for clean-up and future use. Although the property area is currently zoned for industrial use, clean up activities achieved levels for residential use in Zone A, recreational use in Zone B and industrial use in Zone E. Clean-up standards were developed based on the City's 20-Year Master Plan for future uses in the area.

Question C: **Has any other information come to light that could call into question the protectiveness of the remedy?** NO. The remedy selected for Tannery Bay required at least three rounds of biological monitoring. A baseline was conducted pre-construction and one post-construction event was conducted in the summer of 2000. The third event is being planned for the summer of 2005. Therefore, sufficient data collection to determine whether the sediments are, or will cause, a long-term concern for the benthic organisms has not taken place. Per the approved O&M Plan, a minimum of three biological monitoring events were to take place in order to collect sufficient data to evaluate bioaccumulation or uptake of COCs into organisms. Following the second post-construction monitoring event, tissue chemistry data will be statistically analyzed compared to baseline values to determine whether a discernable trend exists in metals accumulation. This trend analysis will then facilitate an evaluation of the effectiveness of the remedy in protecting benthic organisms and wildlife inhabiting Tannery Bay and utilizing river areas adjacent to the Cannelton Industries site.

Phelps Dodge Corp., the current owner of the Cannelton Site, has proposed to remove contaminated sediments from Tannery Bay under a Great Lakes Legacy Act (GLLA) proposal, which was submitted to EPA-Great Lakes National Program Office (GLNPO) in March 2004. The proposed work would be funded by Phelps Dodge and EPA-GLNPO and implemented by GLNPO should GLNPO accept the project design. The proposed dredging project would go beyond that required in the ROD Amendment and if it is properly designed and properly implemented, the biomonitoring component of the O&M Plan should verify a significant decrease in bioavailability of COCs. EPA Superfund program would consider this to be a betterment of the environment. The potential does exist, however, that through incomplete design or improper implementation of the proposed dredging, bioavailability of site-related COCs could actually increase, thereby decreasing the protectiveness of the remedy.

No other information that could affect the protectiveness of the remedy was found as a result of this review.

Technical Assessment Summary

This Review found the remedy implemented at the Site to be working as intended by the ROD Amendment. Excavation of the most contaminated soils and tannery waste eliminated the source of contamination for the Site. Clean-up standards for the upland areas were selected based on future land use in the 20-Year Master Plan for the City of Sault Ste. Marie.

Sediments were left on site to allow for natural recovery. Long-term monitoring was required in the form of physical monitoring for the shoreline protection, biological monitoring to ensure no accumulation of remaining metals in the sediments to benthic organisms, and surface water monitoring. There has not been sufficient data collected to make the determination for long-term protectiveness for the remedy selected in Tannery Bay and the Wetland Area.

Based on the monitoring data for the site, the remedy is protective in the short term. Long-term protectiveness will be verified in the next five-year review.

VIII. Issues

No major issues were found as a result of this review that affects the current protectiveness of the remedy. One issue documented in this Review is the lack of deed restrictions on the property. This does not affect current protectiveness since the current local zoning remains as Industrial and the site is fenced to prevent traspassing. However, once a determination is made as to the final uses of the property (based on reuse discussions), then deed restrictions where applicable should be implemented as appropriate. Currently, the site remains fenced along South Street to prevent trespassing and vandalism, but no warning signs are posted as a result of the City's request. Other issues documented below are for improvement of site reuse and redevelopment, and the need to complete the partial delisting process.

Table 10: Issues

Issues	Affects Current Protectiveness (Y/N)	Affects Future Protectiveness (Y/N)
Deed Restrictions have not been implemented	**N**	**Y**
Finalize Redevelopment/Reuse for the Site	**N**	**Y**
Finalize Delisting process	**N**	**N**

IX. Recommendations and Follow-up Actions

Table 11: Recommendations and Follow-up Actions

Issue	Recommendations and Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Y/N) Current	Future
ICs	Implement required ICs	Property owner/City?	EPA	June 2006	N	Y
Reuse	Finalize Redevelopment/ Reuse for the Site	Property owner and City	EPA	June 2006	N	Y
NPL delisting	Finalize Delisting process	EPA/MDEQ		June 2006	N	N

In addition to above recommendations, it is recommended that monitoring continue at the site to ensure long-term protectiveness.

X. Protectiveness Statement(s)

The remedy implemented at the Cannelton Site for the upland soils (zones A, B, and E) currently protects human health and the environment as source materials have been removed and residual contamination is below the site-specific cleanup levels that were established to ensure protection of human health and the environment.. However, there remain uncertainties with regard to long-term protectiveness of the remedy for zones C, Wetlands, and D, Tannery Bay. Insufficient data has been collected to date that would allow U.S. EPA to make a determination of long-term protectiveness for these areas. Laboratory geochemical studies were used to infer the stability of contaminants in wetland soils; however, the bioavailability of the COCs in wetland soils to wildlife receptors never was measured under fluctuating environmental conditions. Therefore, the long-term protectiveness of the remedy for wetland receptors remains uncertain. Spatial analysis of sediment deposition patterns during the past two decades support the assumptions in the Amended ROD that Tannery Bay is a net depositional area for sediment and the wetlands of Tannery Point are encroaching on Tannery Bay over the areas of contaminated sediment. However, additional questions remain regarding the effectiveness of the observed sedimentation and wetland encroachment on the anticipated decrease in bioavailability of site COCs.

The following actions need to be taken for the Wetlands:

- continue surface water sampling and additional rounds of groundwater sampling; and

- conduct bioavailability monitoring to confirm whether contaminants in wetland soils are entering the foodchain.

The following actions need to be taken for the Tannery Bay:

- continue surface water sampling and sediment sampling; and

- continue biological monitoring to collect sufficient data to support trend analysis of the bioavailability of COCs in Tannery Bay sediments. Collection of this data will facilitate an evaluation of the effectiveness of the remedy in protecting human health and benthic organisms and wildlife inhabiting Tannery Bay and utilizing river areas adjacent to the Cannelton Industries site.

Long-Term Protectiveness:

Long-term protectiveness for Wetlands and Tannery Bay will be verified in the next Five Year Review.

XI. Next Review

Because the remedy implemented at the Site leaves certain parcels of the Site at levels that will not allow for unrestricted use and unlimited exposure, future Five-Year Reviews are required for the site. The next Review will be conducted 5 years from the date of this Review (August 2009).

TABLES

TABLE 1

FIVE YEAR GROUNDWATER ANALYTICAL SUMMARY
CANNELTON SITE
SAULT STE. MARIE, MICHIGAN

Compound	ARSENIC		CADMIUM		CHROMIUM (III)		CHROMIUM (VI)		LEAD		MERCURY		
Performance Criteria	50		5		100		100		4		2		
Sample Location / ***Date***	Jun-00	Nov-00	Jun-00	Nov-00	Jun-00	Nov-00	Jun-00	Nov-00	Jun-00	Nov-00	Jun-00	Nov-00	Dec-03
UPGRADIENT													
MW-02S (West)	ND(10)	ND(10)	ND(2)	ND(2)	ND(5)	ND(5)	ND(20)	ND(20)	ND(3)	ND(3)	ND(0.2)	ND(0.2)	0.0041
MW-12 (East)	ND(10)	ND(10)	ND(2)	ND(2)	ND(5)	ND(5)	3.8 J	ND(20)	ND(3)	ND(3)	ND(0.2)	ND(0.2)	ND(0.0005)
MW-32 (West)	ND(10)	ND(10)	ND(2)	ND(2)	ND(5)	ND(5)	ND(20)	ND(20)	ND(3)	ND(3)	ND(0.2)	ND(0.2)	NA
MW-32 (West) - MS/MSD	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**0.00054**
DOWNGRADIENT													
MW-04 (West)	ND(10)	NA	ND(2)	NA	ND(5)	NA	ND(20)	NA	ND(3)	NA	ND(0.2)	NA	0.00066
MW-04 (West) - MS/MSD	**NA**	**ND(10)**	**NA**	**0.34 J**	**NA**	**ND(5)**	**NA**	**ND(20)**	**NA**	**ND(3)**	**NA**	**ND(0.2)**	**NA**
MW-47 (West)	ND(10)	ND(10)	ND(2)	0.29 J	ND(5)	ND(5)	ND(20)	ND(20)	ND(3)	ND(3)	ND(0.2)	ND(0.2)	ND(0.0005)
MW-47 (Duplicate)	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**ND(0.0005)**
MW-93-01 (Wetland)	ND(10)	ND(10)	ND(2)	ND(2)	5.8	9.1	ND(20)	ND(20)	ND(3)	ND(3)	ND(0.2)	ND(0.2)	ND(0.0005)
MW-93-01 (Duplicate)	**ND(10)**	**NA**	**ND(2)**	**NA**	**5.5**	**NA**	**ND(20)**	**NA**	**ND(3)**	**NA**	**ND(0.2)**	**NA**	**NA**
MW-93-02 (Wetland)	ND(10)	ND(10)	0.53 J	ND(2)	9.1	7.5	ND(20)	ND(20)	ND(3)	ND(3)	ND(0.2)	ND(0.2)	ND(0.0005)
MW-93-02 (Duplicate)	NA	ND(10)	NA	ND(2)	NA	9.3	NA	ND(20)	NA	ND(3)	NA	ND(0.2)	NA
MW-93-03 (Wetland)	ND(10)	ND(10)	ND(2)	ND(2)	71	30	ND(20)	ND(20)	ND(3)	ND(3)	ND(0.2)	ND(0.2)	ND(0.0005)
MW-93-03 (Duplicate)	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**ND(0.0005)**
MW-101(Former Barren Zone)	ND(10)	ND(10)	ND(2)	ND(2)	ND(5)	ND(5)	ND(20)	ND(20)	ND(3)	ND(3)	ND(0.2)	ND(0.2)	ND(0.0005)
MW-102 (Former Barren Zone)	NA	ND(10)	NA	0.29 J	NA	ND(5)	NA	ND(20)	NA	ND(3)	NA	ND(0.2)	ND(0.0005)
MW-102 (Former Barren Zone) - MS/MSD	**ND(10)**	**NA**	**ND(2)**	**NA**	**ND(5)**	**NA**	**ND(20)**	**NA**	**ND(3)**	**NA**	**ND(0.2)**	**NA**	**NA**
MW-103 (Former Barren Zone)	ND(10)	ND(10)	ND(2)	ND(2)	45	44	ND(20)	ND(20)	ND(3)	ND(3)	ND(0.2)	ND(0.2)	ND(0.0005)
Field Blank	**NA**	**ND(10)**	**NA**	**ND(2)**	**NA**	**ND(5)**	**ND(20)**	**ND(20)**	**NA**	**ND(3)**	**NA**	**ND(0.2)**	**NA**
Field Blank	**ND(10)**	**ND(10)**	**ND(2)**	**ND(2)**	**ND(5)**	**ND(5)**	**ND(20)**	**ND(20)**	**ND(3)**	**ND(3)**	**ND(0.2)**	**ND(0.2)**	**NA**
Field Blank	**ND(10)**	**ND(10)**	**ND(2)**	**ND(2)**	**ND(5)**	**ND(5)**	**2.8 J**	**ND(20)**	**ND(3)**	**ND(3)**	**ND(0.2)**	**ND(0.2)**	**ND(0.0005)**

Notes:
All units reported in micrograms per liter with the exception of Total Hardness and TOC, which are shown.
NA - Not analyzed
ND ( ) - Not detected above the laboratory reporting limit stated in parentheses
J - Estimated result. Result is below the laboratory reporting limit.
Boxed values represent exceedance of the performance criteria.
Bolded samples represent QA/QC samples.

TABLE 2

FIVE YEAR SURFACE WATER ANALYTICAL SUMMARY
CANNELTON SITE
SAULT STE. MARIE, MICHIGAN

Compound	*ARSENIC*			*CADMIUM*			*CHROMIUM (III)*			*CHROMIUM (VI)*		
Performance Criteria	*180*			*0.37*			*43.6*			*7.3*		
Sample Location / *Date*	*Jun-00*	*Nov-00*	*Dec-03*	*Jun-00*	*Nov-00*	*Dec-03*	*Jun-00*	*Nov-00*	*Dec-03*	*Jun-00*	*Nov-00*	*Dec-03*
SW-1 (Isaac Walton Bay)	ND(10)	ND(10)	ND(10)	ND(2)	ND(2)	ND (0.36)*	ND(5)	ND(5)	ND(5)	7.9 J	ND(20)	ND(5)*
SW-1 (Duplicate)	**ND(10)**	**NA**	**NA**	**0.4 J**	**NA**	**NA**	**ND(5)**	**NA**	**NA**	**11.8 J**	**NA**	**NA**
SW-2 (Seymour Creek)	ND(10)	ND(10)	ND(10)	ND(2)	ND(2)	0.37 J	ND(5)	ND(5)	ND(5)	28.6	ND(20)	ND(5)*
SW-3 (Upstream)	ND(10)	ND(10)	ND(10)	ND(2)	ND(2)	ND (0.36)*	ND(5)	ND(5)	ND(5)	ND(20)	ND(20)	ND(5)*
SW-4 (Upstream)	ND(10)	ND(10)	ND(10)	ND(2)	ND(2)	ND (0.36)*	ND(5)	ND(5)	ND(5)	ND(20)	ND(20)	ND(5)*
SW-4 (Duplicate)	**NA**	**ND(10)**	**ND(10)**	**NA**	**ND(2)**	**ND (0.36)***	**NA**	**ND(5)**	**ND(5)**	**NA**	**ND(20)**	**ND(5)***
SW-5 (along berm)	ND(10)	ND(10)	ND(10)	ND(2)	ND(2)	ND (0.36)*	ND(5)	ND(5)	ND(5)	ND(20)	ND(20)	ND(5)*
SW-6 (along berm)	ND(10)	ND(10)	ND(10)	ND(2)	ND(2)	ND (0.36)*	ND(5)	ND(5)	ND(5)	ND(20)	ND(20)	ND(5)*
SW-6 (Duplicate)	**ND(10)**	**NA**	**NA**	**ND(2)**	**NA**	**NA**	**ND(5)**	**NA**	**NA**	**ND(20)**	**NA**	**NA**
SW-7 (along berm)	ND(10)	ND(10)	ND(10)	ND(2)	0.29 J	ND (0.36)*	ND(5)	ND(5)	ND(5)	ND(20)	ND(20)	ND(5)*
SW-8 (Tannery Bay - NW)	ND(10)	ND(10)	ND(10)	ND(2)	ND(2)	ND (0.36)*	13	23	ND(5)	ND(20)	ND(20)	ND(5)*
SW-8 (Duplicate)	**NA**	**ND(10)**	**NA**	**NA**	**ND(2)**	**NA**	**NA**	**10**	**NA**	**NA**	**ND(20)**	**NA**
SW-9 (Tannery Bay - SW)	ND(10)	ND(10)	ND(10)	0.47 J	ND(2)	ND (0.36)*	79	26	63	11.8 J	ND(20)	ND(5)*
SW-10 (Tannery Bay - SE)	ND(10)	ND(10)	ND(10)	ND(2)	0.29 J	ND (0.36)*	30	ND(5)	ND(5)	ND(20)	ND(20)	ND(5)*
SW-11 (Tannery Bay - NE)	ND(10)	ND(10)	ND(10)	ND(2)	0.34 J	ND (0.36)*	ND(5)	ND(5)	ND(5)	ND(20)	ND(20)	ND(5)*
SW-11 (Duplicate)	**NA**	**NA**	**ND(10)**	**NA**	**NA**	**ND (0.36)***	**NA**	**NA**	**ND(5)**	**NA**	**NA**	**ND(5)***
SW-12 (Long Pond)	ND(10)	ND(10)	ND(10)	0.28 J	ND(2)	0.66 J	9.7	13	100	4.0 J	ND(20)	ND(5)*

Notes:

All units reported in micrograms per liter with the exception of Total Hardness and TOC, which are shown.
NA - Not analyzed
ND ( ) - Not detected above the laboratory reporting limit stated in parentheses.
ND ( )* - Not detected above the laboratory method detection limit stated in parentheses.
J - Estimated result. Result is below the laboratory reporting limit.
Boxed values represent exceedance of the performance criteria.
Bolded samples represent QA/QC samples.

TABLE 2

FIVE YEAR SURFACE WATER ANALYTICAL SUMMARY
CANNELTON SITE
SAULT STE. MARIE, MICHIGAN

Compound	*LEAD*			*MERCURY*			*TOTAL HARDNESS (mg/l)*			*TOC (mg/l)*		
Performance Criteria	3			0.0013/0.2			--			--		
Sample Location *Date*	*Jun-00*	*Nov-00*	*Dec-03*	*Jun-00*	*Nov-00*	*Dec-03*	*Jun-00*	*Nov-00*	*Dec-03*	*Jun-00*	*Nov-00*	*Dec-03*
SW-1 (Isaac Walton Bay)	ND(3)	ND(3)	ND(3)	ND(0.2)	ND(0.2)	0.0016	42	42	43	1	ND(1)	2
SW-1 (Duplicate)	**ND(3)**	**NA**	**NA**	**ND(0.2)**	**NA**	**NA**	**42**	**NA**	**NA**	**2**	**NA**	**NA**
SW-2 (Seymour Creek)	3.3	ND(3)	ND(3)	ND(0.2)	ND(0.2)	0.0059	69	90	46	14	8	8
SW-3 (Upstream)	ND(3)	ND(3)	ND(3)	ND(0.2)	ND(0.2)	ND(0.0005)	42	48	46	1	ND(1)	1
SW-4 (Upstream)	ND(3)	ND(3)	ND(3)	ND(0.2)	ND(0.2)	ND(0.0005)	42	87	48	2	ND(1)	1
SW-4 (Duplicate)	**NA**	**ND(3)**	**ND(3)**	**NA**	**ND(0.2)**	**ND(0.0005)**	**NA**	**42**	**42**	**NA**	**ND(1)**	**3**
SW-5 (along berm)	ND(3)	ND(3)	ND(3)	ND(0.2)	ND(0.2)	0.0011	42	34	48	2	ND(1)	2
SW-6 (along berm)	ND(3)	ND(3)	ND(3)	ND(0.2)	ND(0.2)	0.0011	44	34	52	1	1	2
SW-6 (Duplicate)	**ND(3)**	**NA**	**NA**	**ND(0.2)**	**NA**	**NA**	**42**	**NA**	**NA**	**1**	**NA**	**NA**
SW-7 (along berm)	ND(3)	ND(3)	ND(3)	ND(0.2)	ND(0.2)	0.0013	42	63	53	2	1	2
SW-8 (Tannery Bay - NW)	ND(3)	ND(3)	ND(3)	ND(0.2)	ND(0.2)	0.00098	42	59	88	2	1	2
SW-8 (Duplicate)	**NA**	**ND(3)**	**NA**	**NA**	**ND(0.2)**	**NA**	**NA**	**61**	**NA**	**NA**	**ND(1)**	**NA**
SW-9 (Tannery Bay - SW)	ND(3)	ND(3)	ND(3)	ND(0.2)	ND(0.2)	0.0073	150	140	180	3	2	1
SW-10 (Tannery Bay - SE)	ND(3)	ND(3)	ND(3)	ND(0.2)	ND(0.2)	0.00098	92	59	55	2	2	2
SW-11 (Tannery Bay - NE)	ND(3)	ND(3)	ND(3)	ND(0.2)	ND(0.2)	0.00098	46	63	49	2	1	2
SW-11 (Duplicate)	**NA**	**NA**	**ND(3)**	**NA**	**NA**	**0.001**	**NA**	**NA**	**56**	**NA**	**NA**	**2**
SW-12 (Long Pond)	ND(3)	ND(3)	3.5	ND(0.2)	ND(0.2)	0.0081	150	150	170	2	ND(1)	2

Notes:

All units reported in micrograms per liter with the exception of Total Hardness and TOC, which are shown.

NA - Not analyzed

ND ( ) - Not detected above the laboratory reporting limit stated in parentheses or above the method detection limit.

J - Estimated result. Result is below the laboratory reporting limit.

Boxed values represent exceedance of the performance criteria.

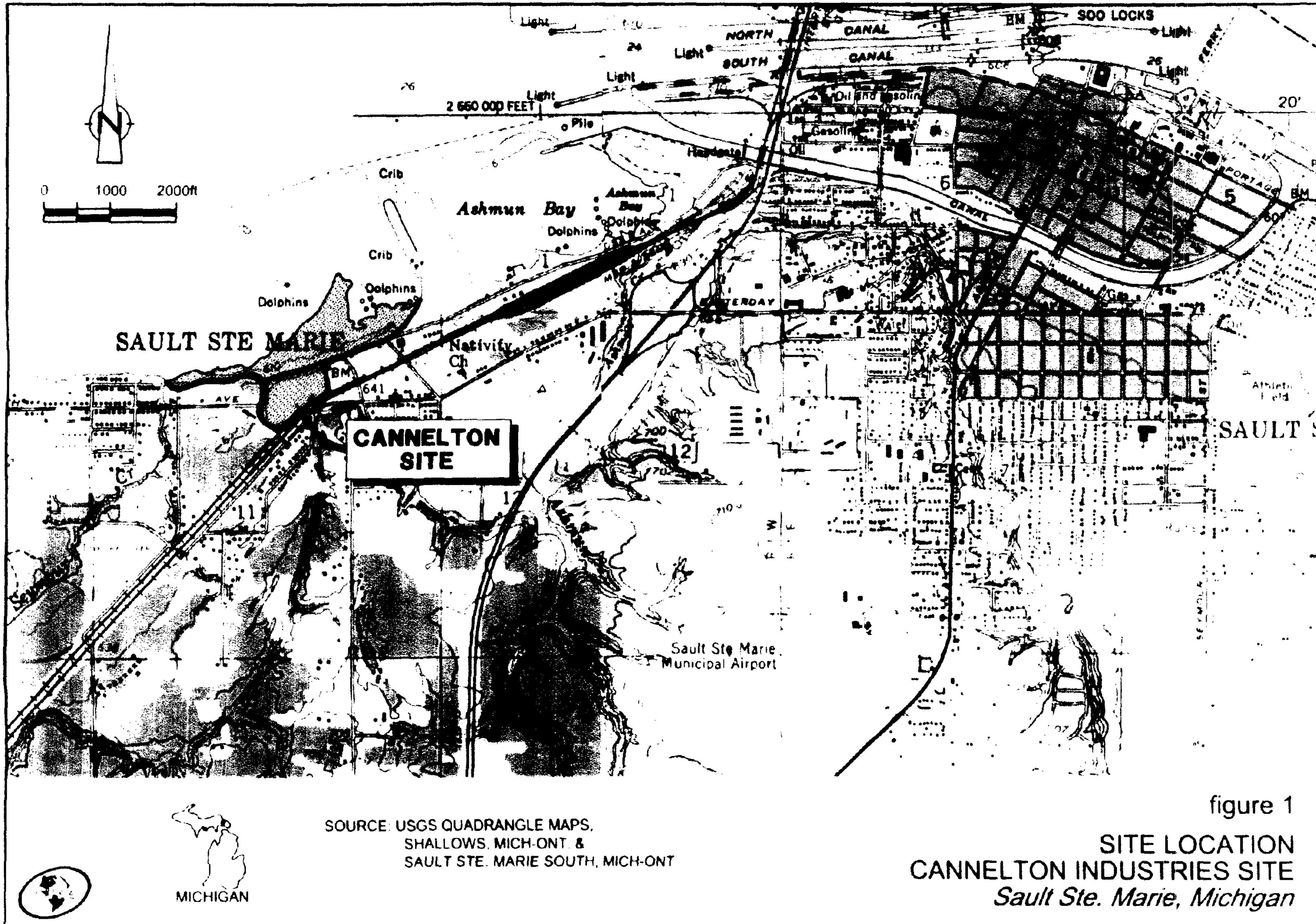
Bolded samples represent QA/QC samples.

TABLE 3

Surface Water Standards
(Based on hardness of 80 mg/L)

Chemical	**Standard (ug/L)**	**Basis**
Arsenic	180	Act 245, Rule 57 (2)
Cadmium	0.37	Act 245, Rule 57 (2)
Chromium, tri	43.6	Act 245, Rule 57 (2)
Chromium, hex	7.3	Act 245, Rule 57 (2)
Lead	3	MDL
Mercury	0.0013/0.2	Act 245,R57(2)/MDL

FIGURES



SOURCE: USGS QUADRANGLE MAPS,
SHALLOWS, MICH-ONT. &
SAULT STE. MARIE SOUTH, MICH-ONT

figure 1

SITE LOCATION
CANNELTON INDUSTRIES SITE
Sault Ste. Marie, Michigan

04093-00(PRES008)GN-WA001 MAY 25/2004

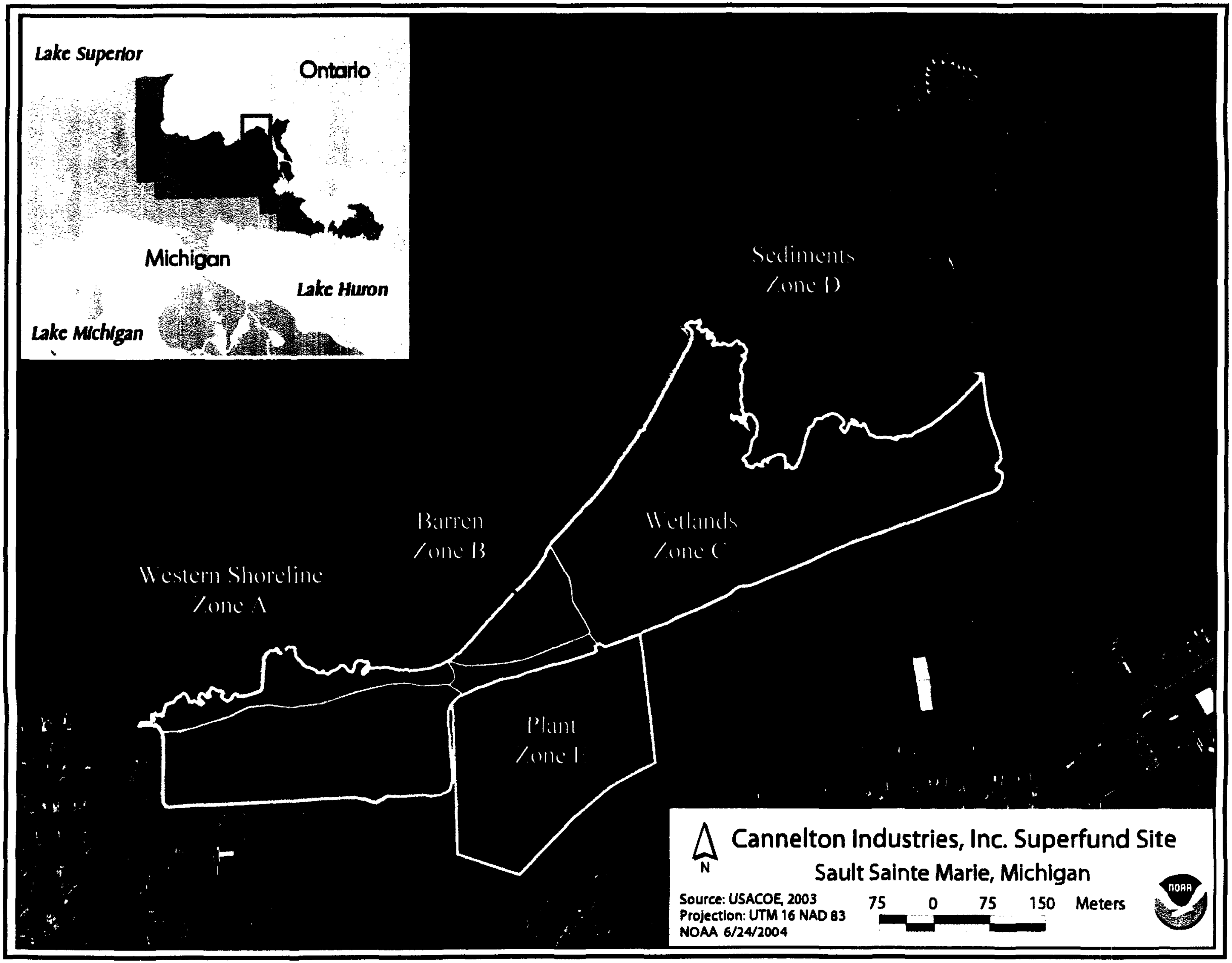


Figure 2. Site Plan Overview

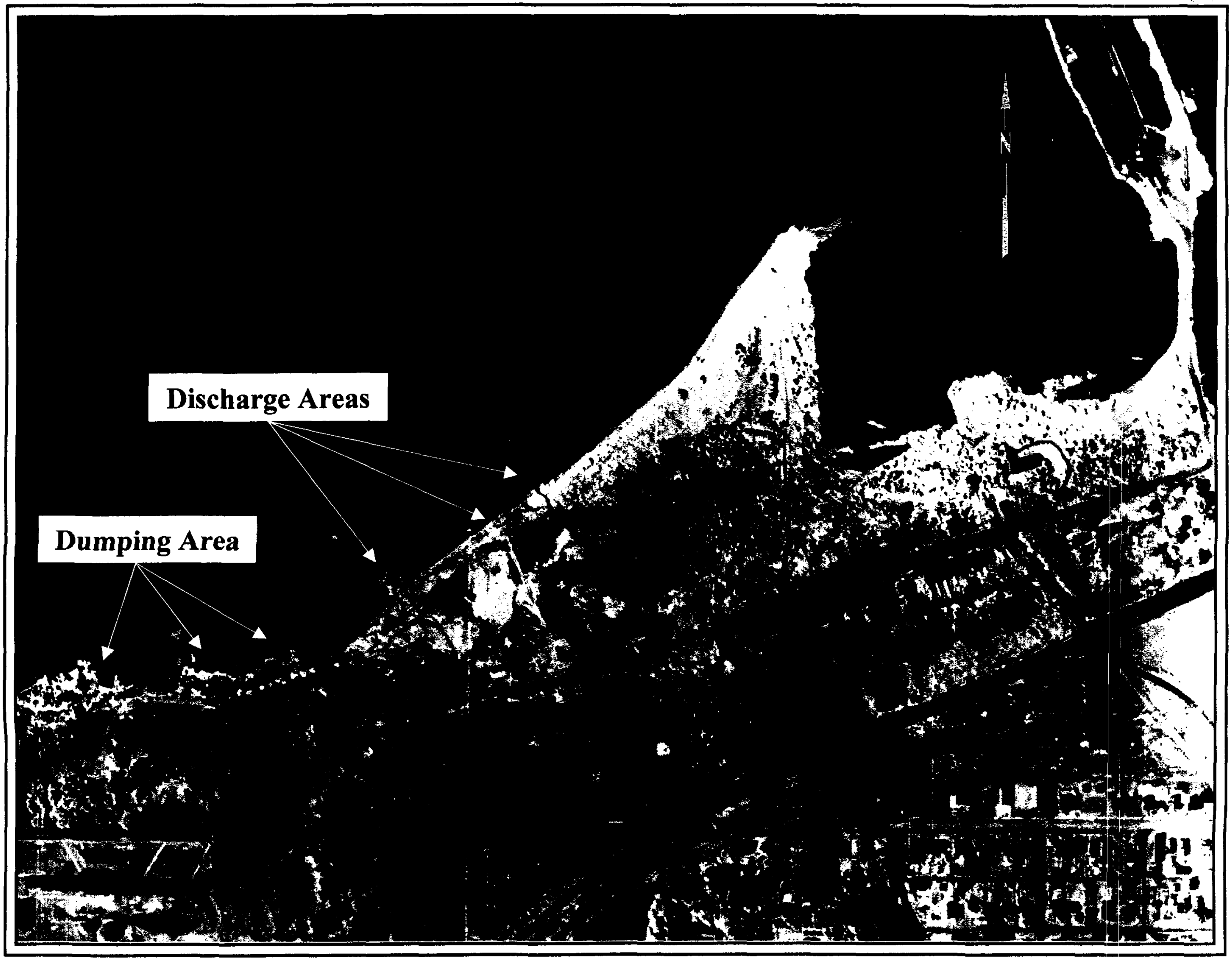


Figure 3. Tannery Plant and Discharge and General Waste Dumping Areas, August 10, 1953

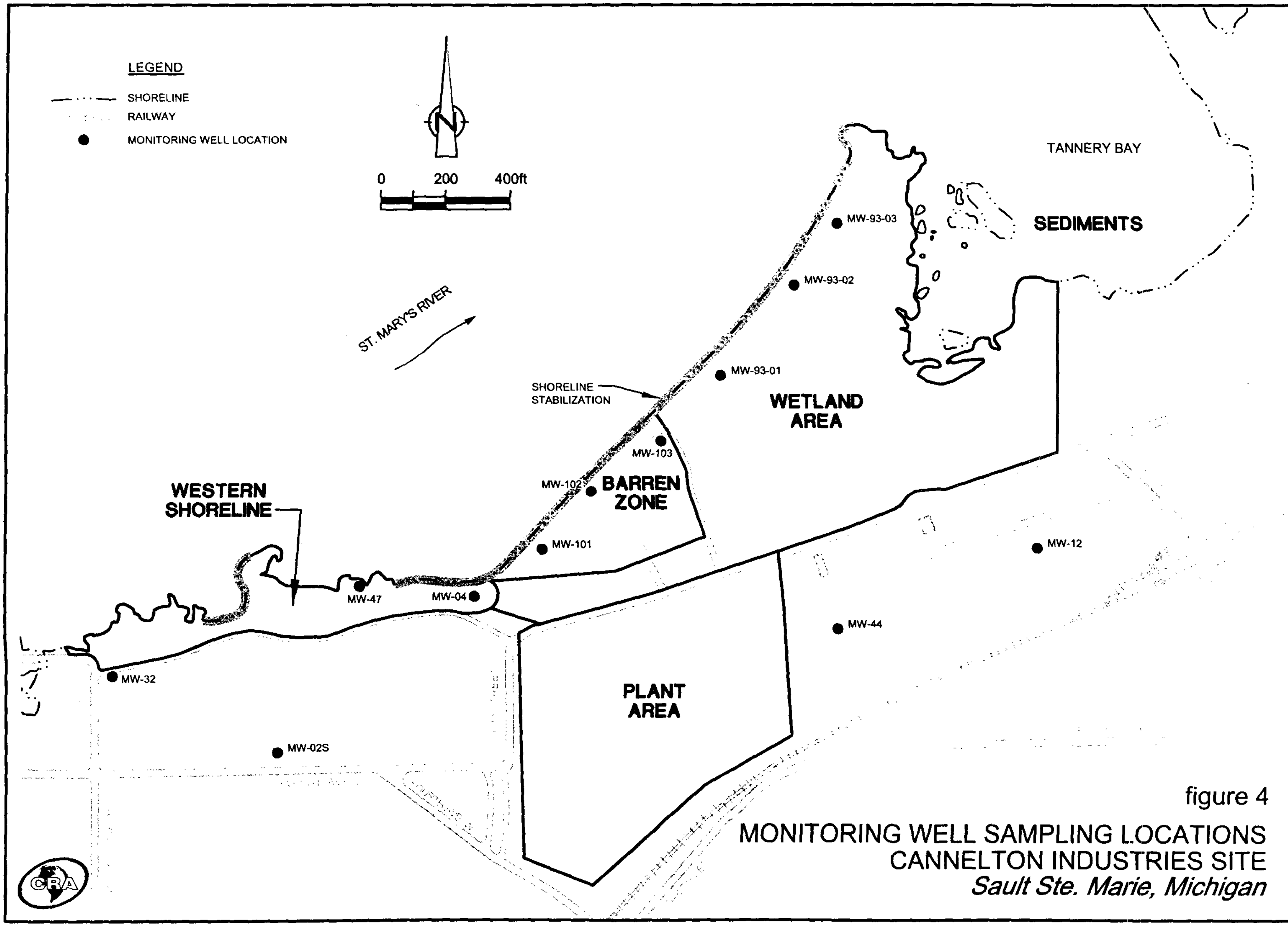


figure 4

MONITORING WELL SAMPLING LOCATIONS
CANNELTON INDUSTRIES SITE
Sault Ste. Marie, Michigan

04093-00(PRES008)GN-WA004 MAY 25/2004

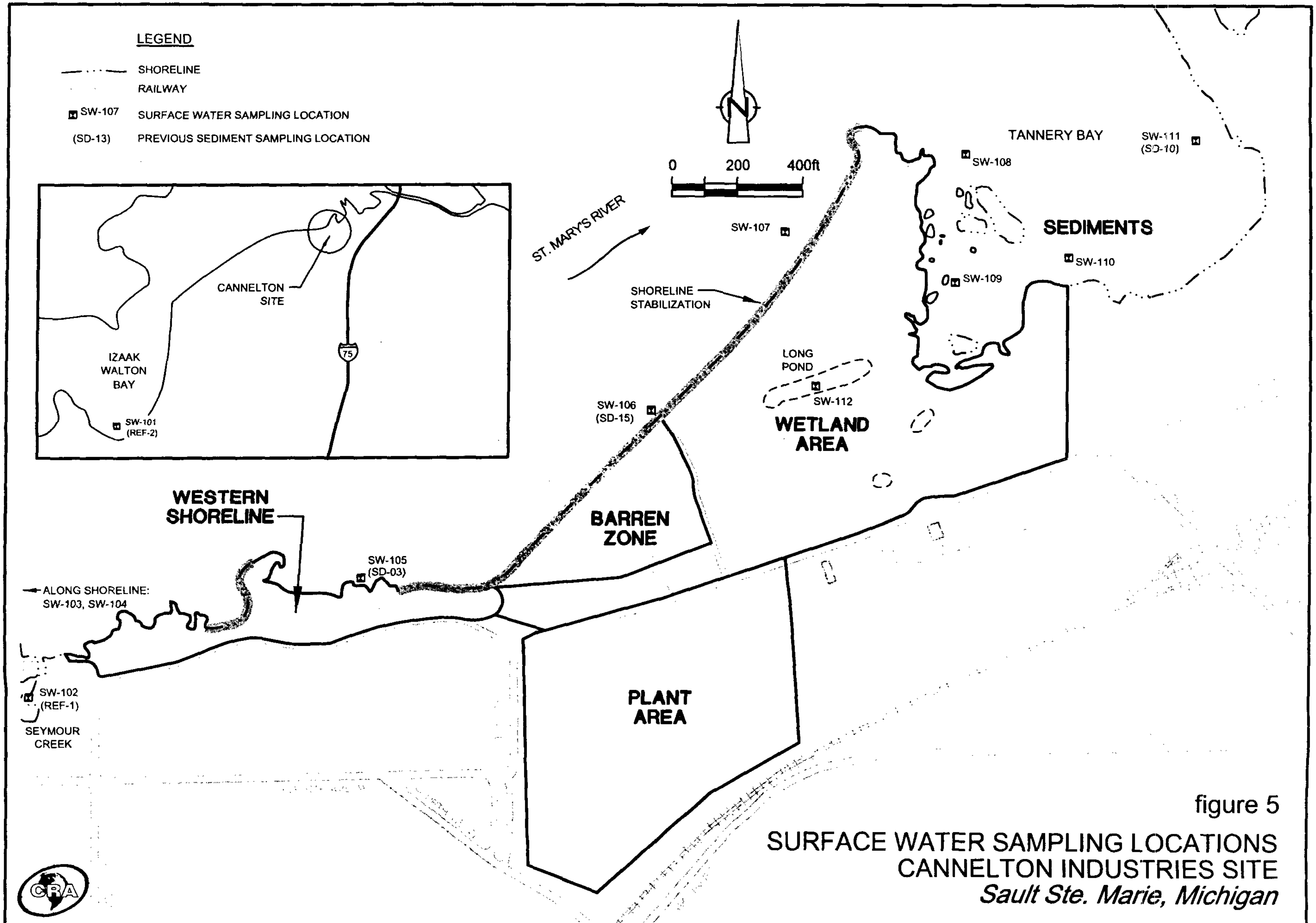


figure 5

SURFACE WATER SAMPLING LOCATIONS
CANNELTON INDUSTRIES SITE
Sault Ste. Marie, Michigan

04093-00(PRES008)GN-WA005 MAY 25/2004

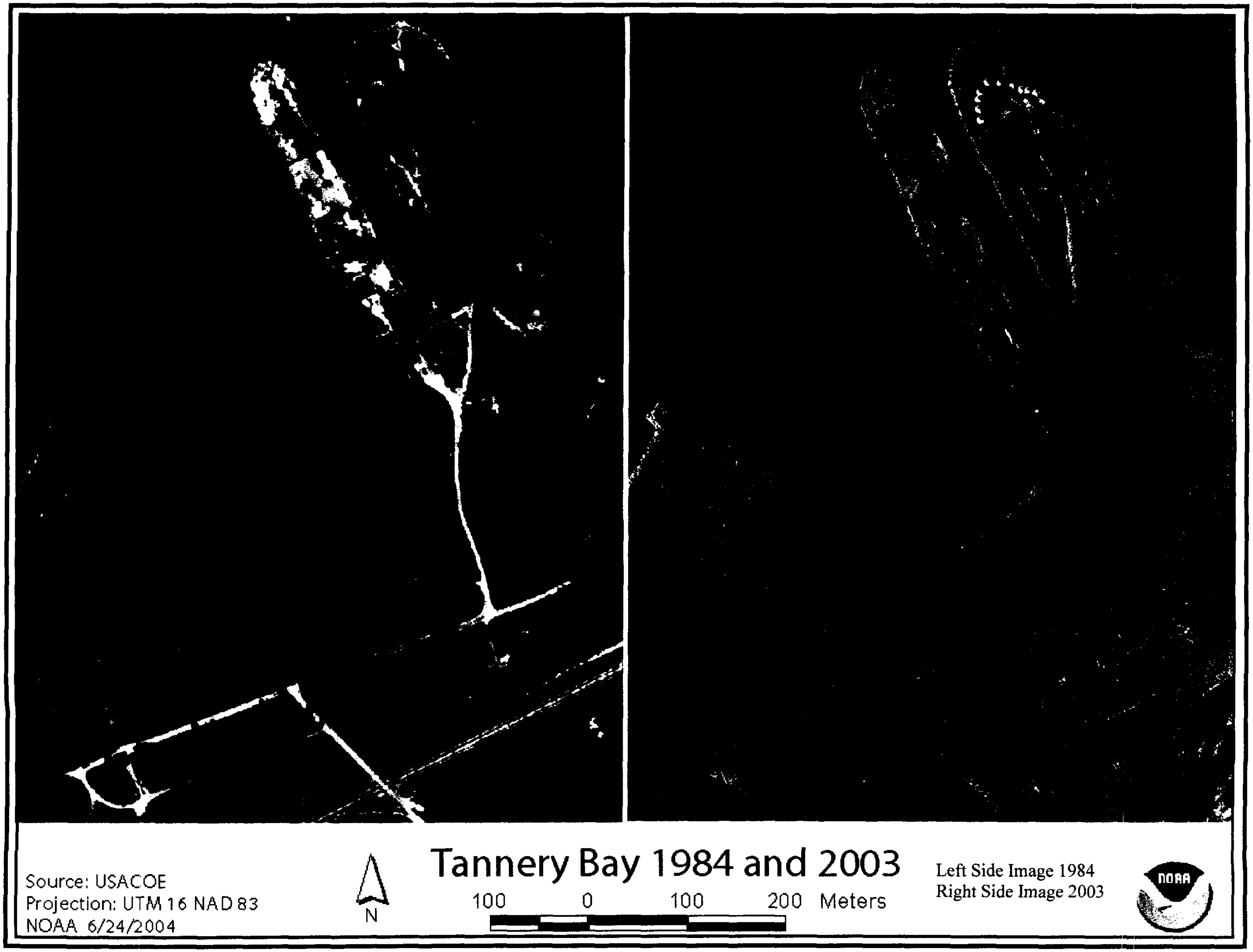


Figure 6. Tannery Bay, 1984 and 2003

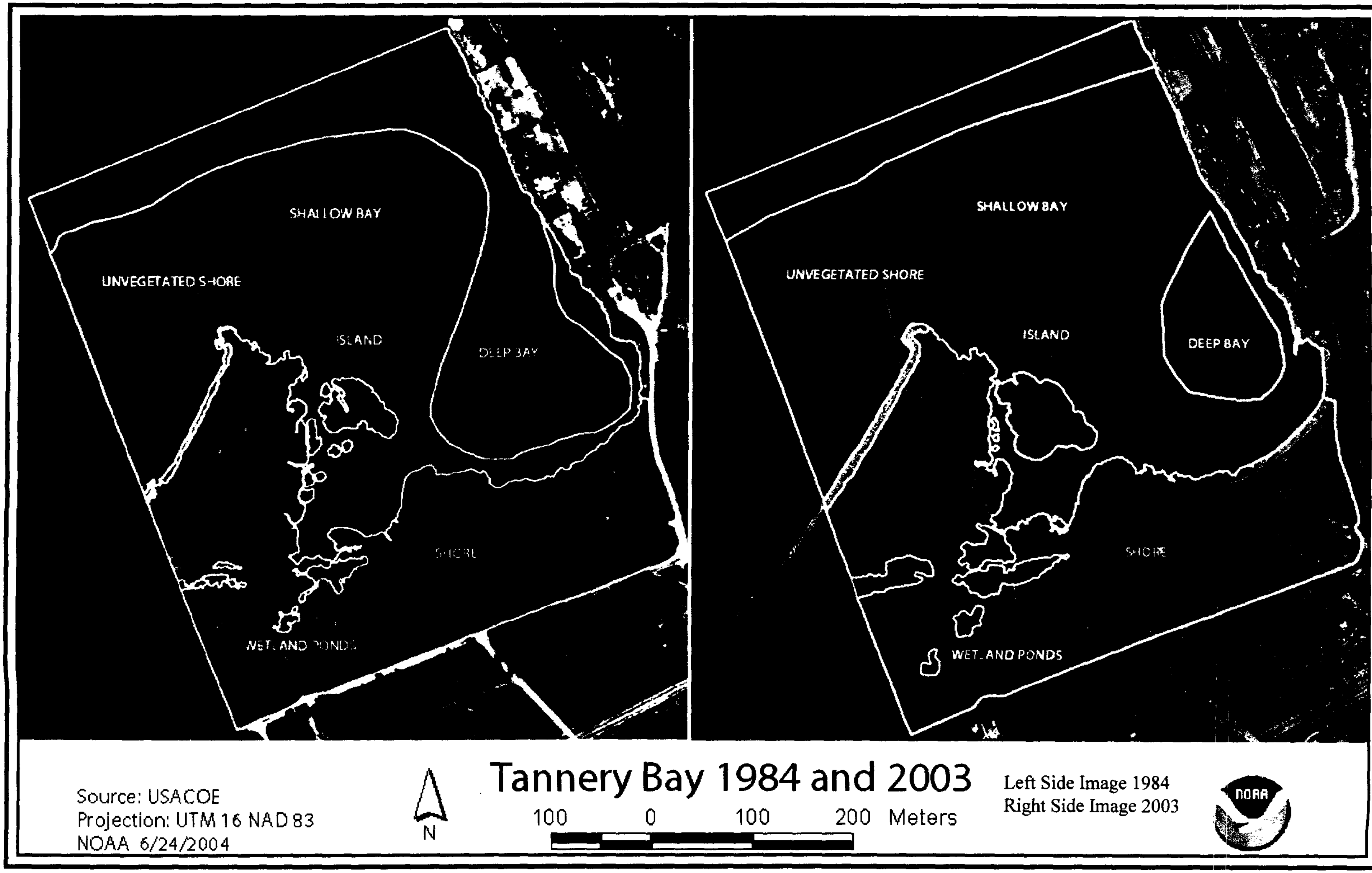


Figure 7. 1984 and 2003 Land/Water Classifications

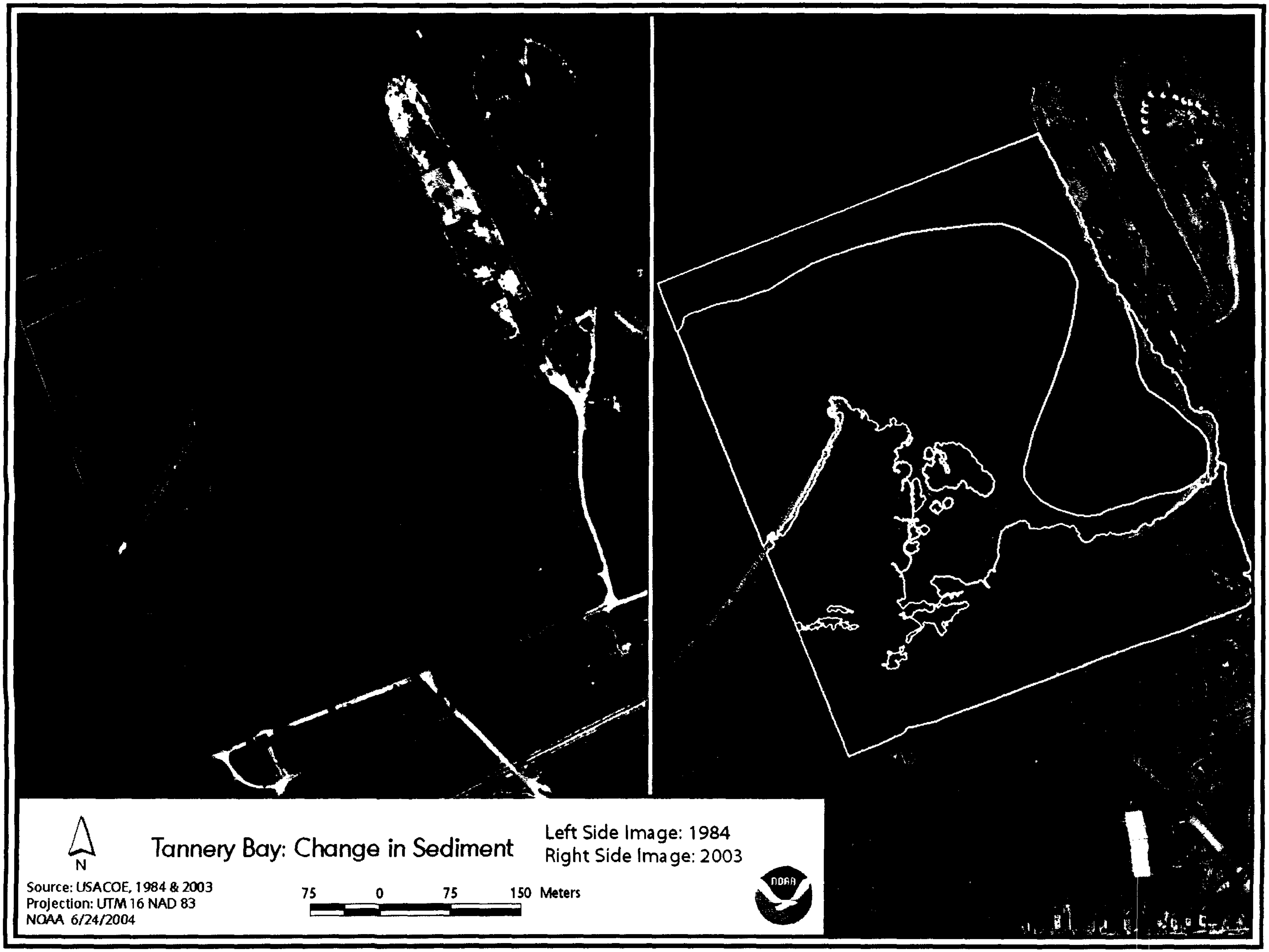


Figure 8. Change in Sediment Extent

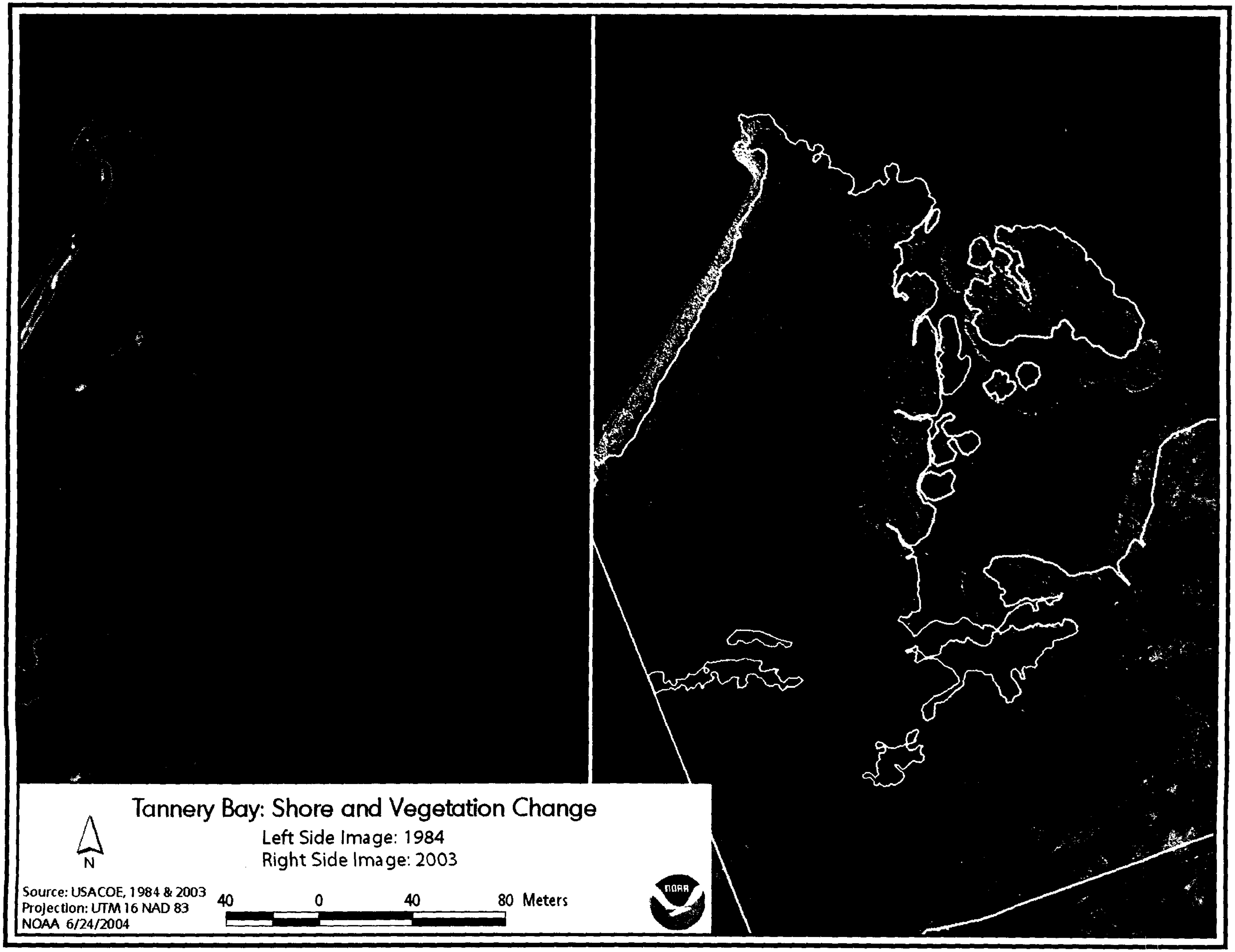


Figure 9. Change in Vegetative Cover

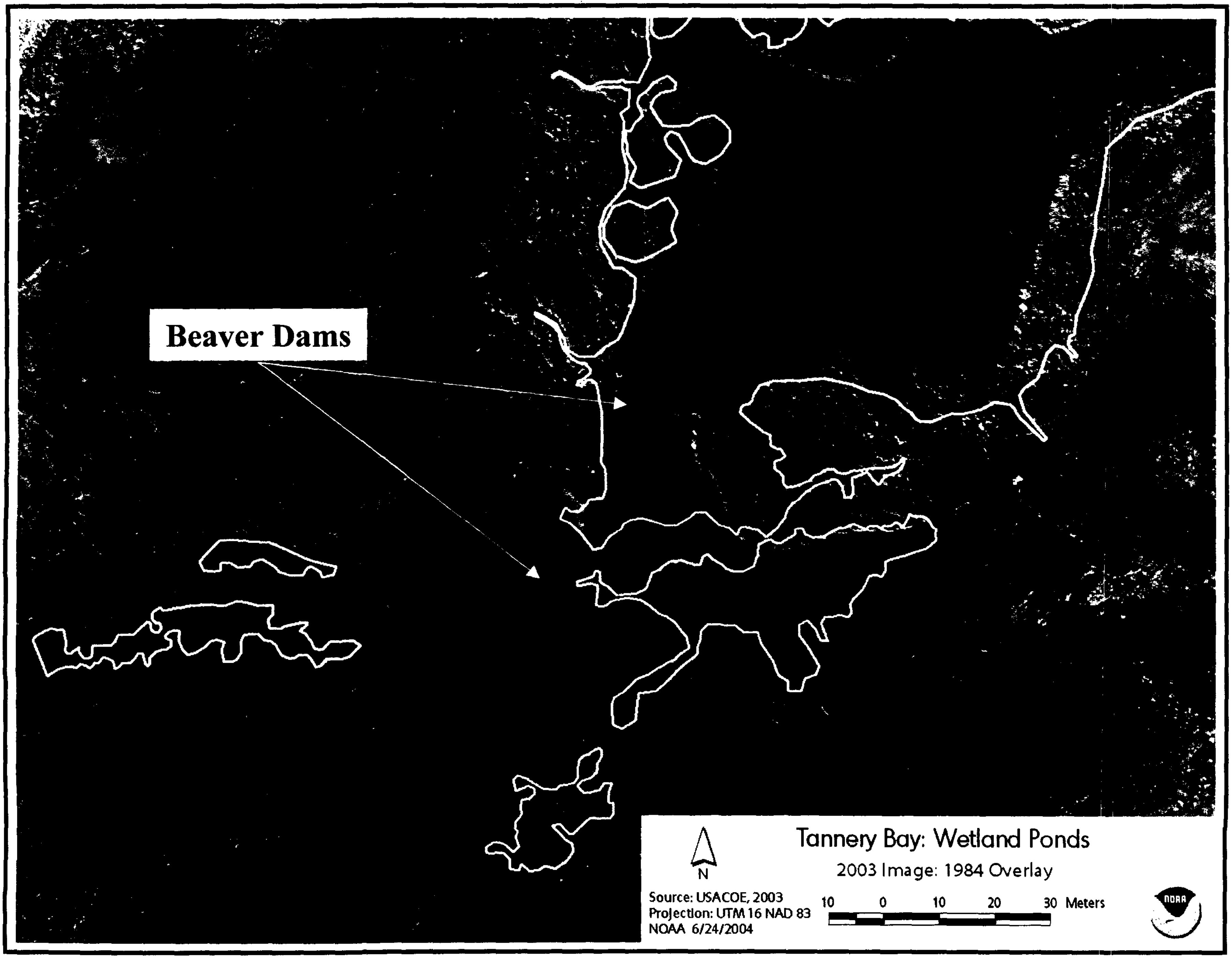


Figure 10. Change in Wetland Ponds

Appendix A - List of Documents Reviewed

1. U.S. EPA, Record of Decision for the Cannelton Ind. Site, September 30, 1992.
2. U.S. EPA, Habitat Survey, Cannelton Industries Site, August 1992
3. U.S. EPA, Statement of Work for Remedial Design at the Cannelton Ind. Site, March 24, 1993.
4. CRA, Remedial Design Pre-Design Studies Report, October 1994, Revised January 5, 1995.
5. CRA, HydroQual, Inc., Bioaccumulation Studies, Cannelton Industries Inc. Site, April 1995.
6. U.S. EPA, ERT, Ecological Risk Assessment for the Cannelton Industries, Inc. Site, January 1995.
7. U.S. EPA, Revised Proposed Plan, Cannelton Ind. Site, May 1996.
8. U.S. EPA, Declaration of Amended Record of Decision, Cannelton Ind. Site, September 27, 1996.
9. NOAA and EVS, Baseline Clam Monitoring Study report, September 1998.
10. MSU, Effects of Environmental Parameters on the Mobility of Chromium in Soils at the Cannelton Industries Site, October 1999.
11. CRA, Construction Completion Report, Cannelton Industries Site, December 1999.
12. CRA, Operation and Maintenance Plan (OMP), Cannelton Industries, Inc. Site, November 1999, Approved by U.S. EPA, June 2000.
13. CRA, Interim Remedial Action Report, Cannelton Industries Site, June 2002
14. HydroQual Inc. (Phelps Dodge), November 2002, Post-Baseline Clam Monitoring Study – Summer 2000-.

Appendix B - Site Photos Documenting Site Conditions

Appendix B

Site Current Conditions
Photographs Taken in June 2004
During Site Inspection

Tannery Bay –Shoreline Protection- Looking East

Tannery Bay –Shoreline Protection-Looking Southeast

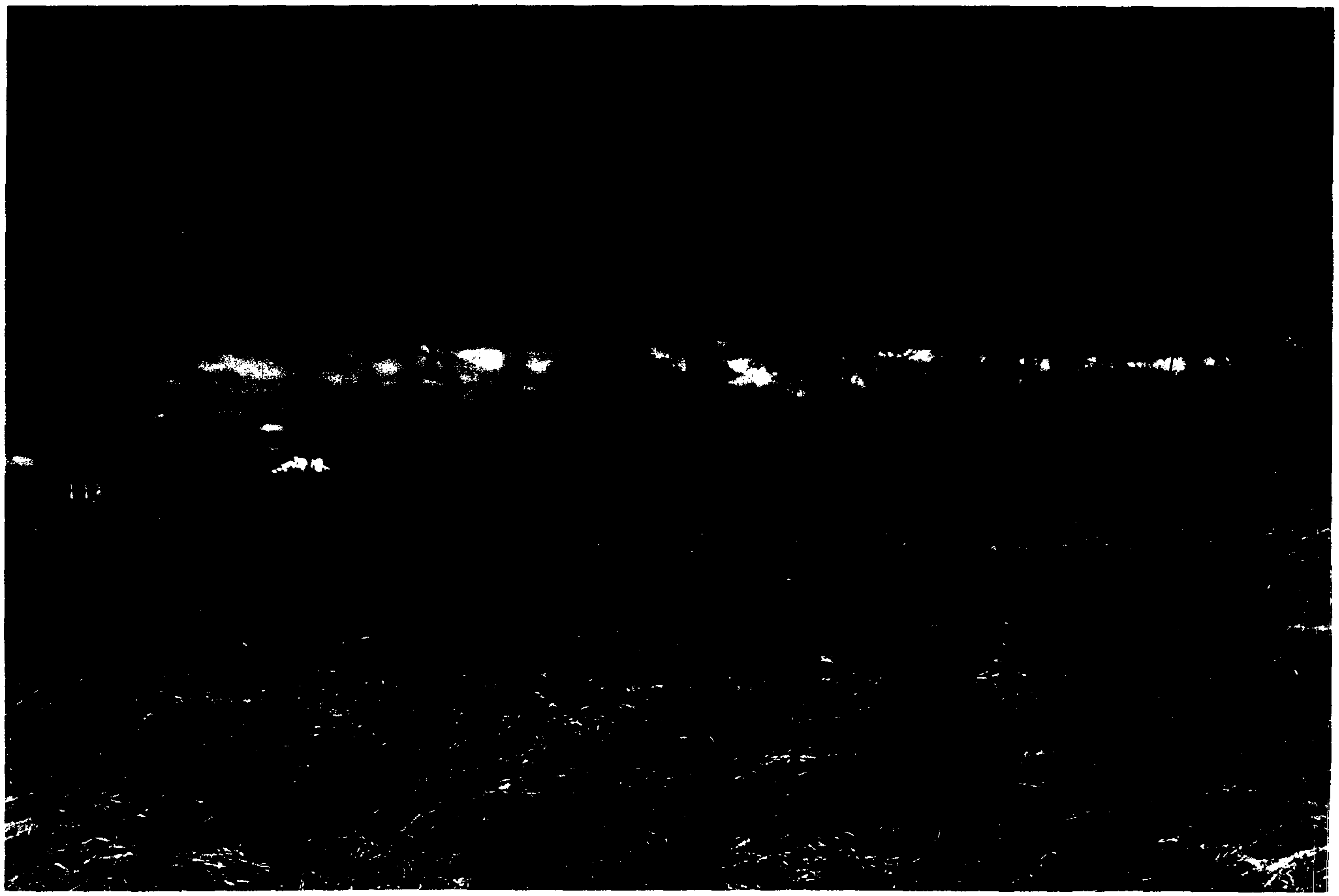
Tannery Bay -Shoreline Protection- Looking West

Tannery Bay –Southwest Corner –Looking West

Western Shoreline Protection -Looking West-

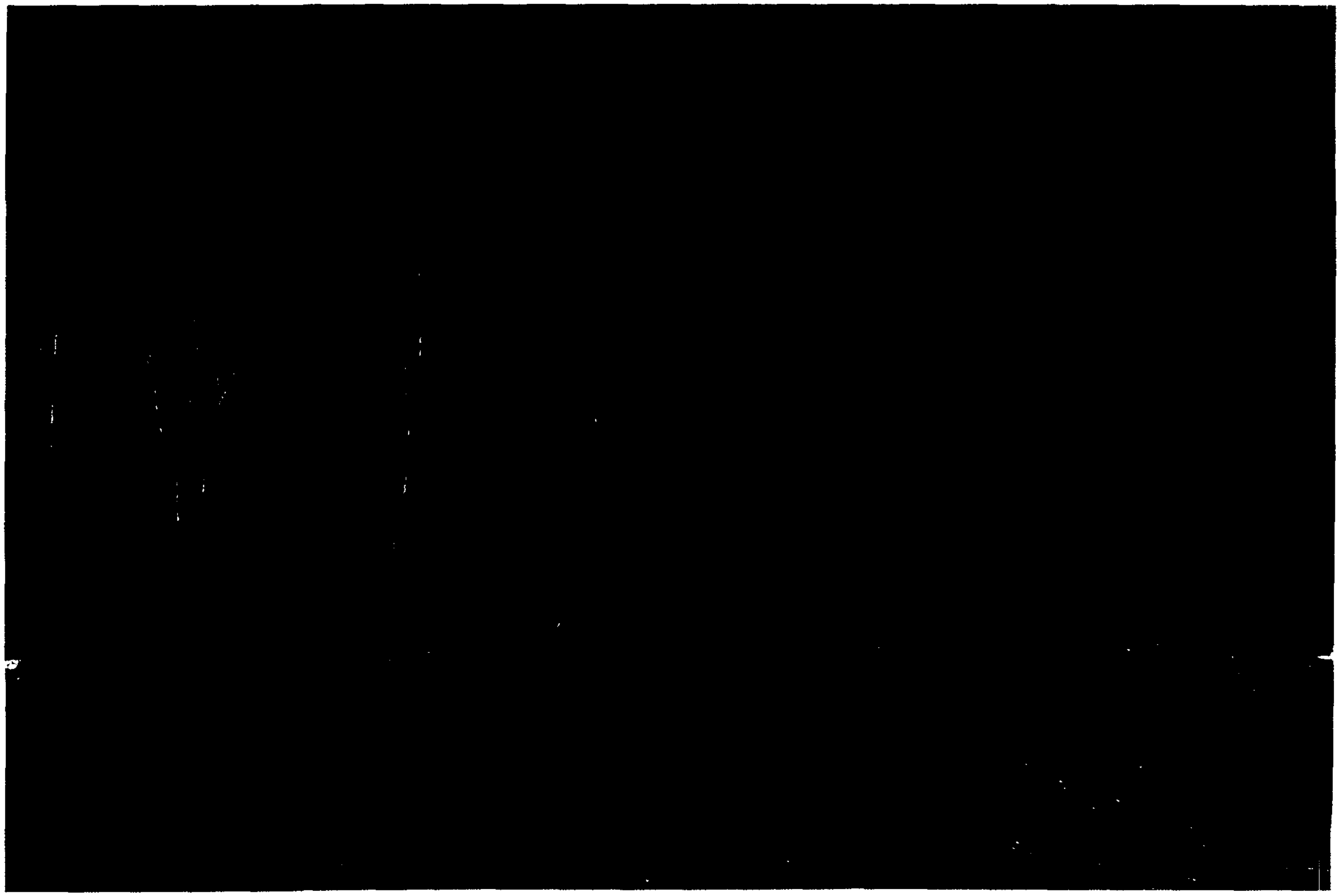
Shoreline Protection and Former Barren Zone (Zone B)

Former Barren Zone -Looking Northeast towards Wetlands area-

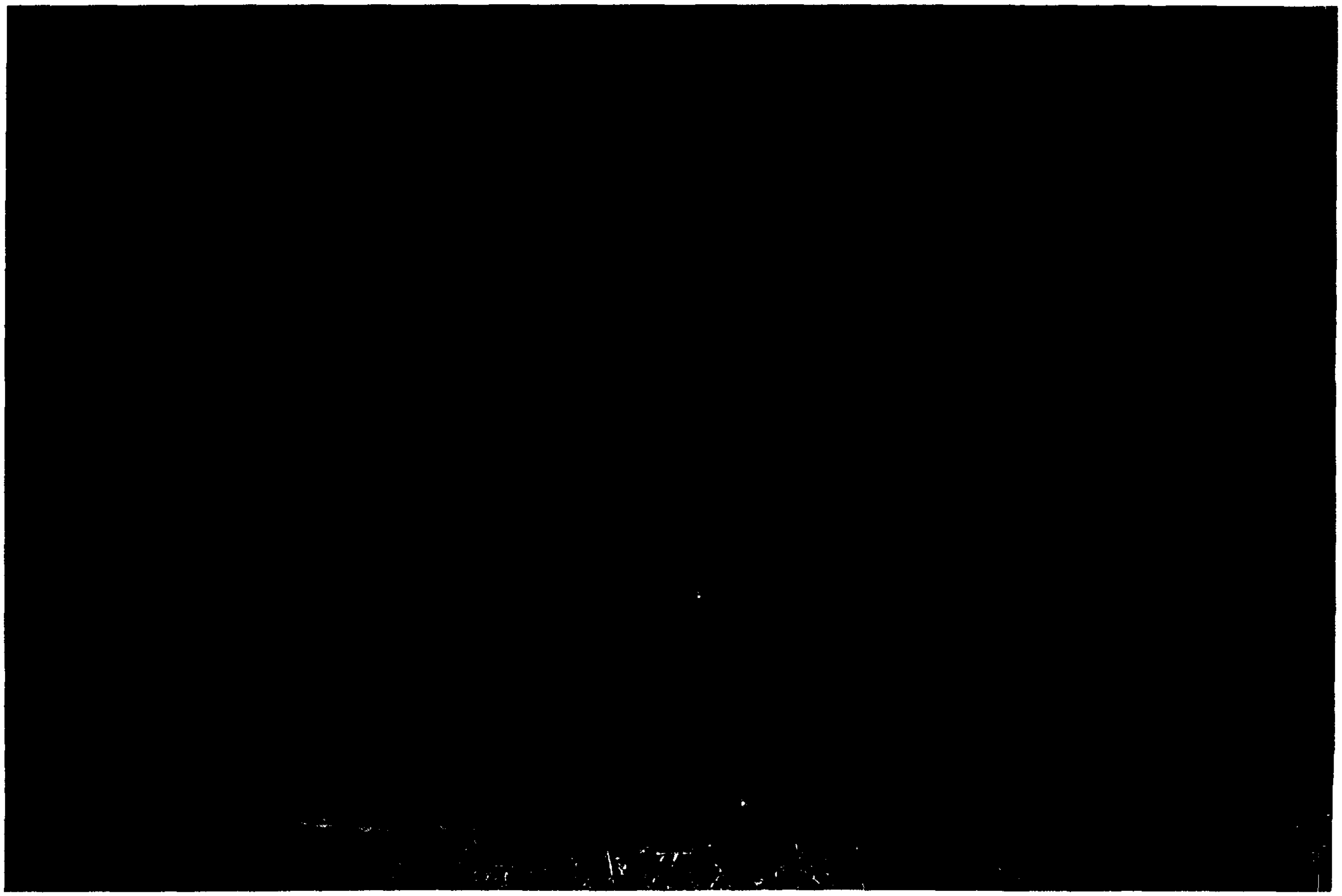


Former Plant Area –Northwest corner-

Former Plant Area (Zone E) –West Entrance Limit-



Former Barren Zone -Looking Northwest-



Wetland Area -Western limit-

Appendix C - Site Inspection CheckList

Please note that "O&M" is referred to throughout this checklist. At sites where Long-Term Response Actions are in progress, O&M activities may be referred to as "system operations" since these sites are not considered to be in the O&M phase while being remediated under the Superfund program.

Five-Year Review Site Inspection Checklist (Template)

I. SITE INFORMATION

Site name: Cannelton Ind	**Date of inspection:** June 8, 2004
Location and Region: Sault Ste Marie, MI	**EPA ID:**
Agency, office, or company leading the five-year review: USEPA	**Weather/temperature:** Sunny Warm

Remedy Includes: (Check all that apply)

- ☐ Landfill cover/containment
- ☒ Access controls
- ☒ Institutional controls
- ☐ Groundwater pump and treatment
- ☐ Surface water collection and treatment
- ☐ Other shore line protection
- ☐ Monitored natural attenuation
- ☐ Groundwater containment
- ☐ Vertical barrier walls

Attachments: ☐ Inspection team roster attached ☐ Site map attached

II. INTERVIEWS (Check all that apply)

1. **O&M site manager** ____________ ____________ ____________
   Name Title Date
   Interviewed ☐ at site ☐ at office ☐ by phone Phone no. ____________
   Problems, suggestions; ☐ Report attached ____________

2. **O&M staff** ____________ ____________ ____________
   Name Title Date
   Interviewed ☐ at site ☐ at office ☐ by phone Phone no. ____________
   Problems, suggestions; ☐ Report attached ____________

3. **Local regulatory authorities and response agencies** (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices, etc.) Fill in all that apply.

Agency ______________________
Contact ______________________ ______________ ________ __________
Name Title Date Phone no.
Problems; suggestions; ☐ Report attached ______________________________________

Agency ______________________
Contact ______________________ ______________ ________ __________
Name Title Date Phone no.
Problems; suggestions; ☐ Report attached ______________________________________

Agency ______________________
Contact ______________________ ______________ ________ __________
Name Title Date Phone no.
Problems; suggestions; ☐ Report attached ______________________________________

Agency ______________________
Contact ______________________ ______________ ________ __________
Name Title Date Phone no.
Problems; suggestions; ☐ Report attached ______________________________________

4. **Other interviews** (optional) ☐ Report attached.

III. ~~ON-SITE~~ DOCUMENTS & RECORDS VERIFIED (Check all that apply)

1. **O&M Documents**

☒ O&M manual	☒ Readily available	☒ Up to date	☐ N/A
☐ As-built drawings	☐ Readily available	☐ Up to date	☐ N/A
☒ Maintenance logs	☒ Readily available	☒ Up to date	☐ N/A

Remarks Site Files - not needed on Site.

2. **Site-Specific Health and Safety Plan** ☐ Readily available ☒ Up to date ☐ N/A
☐ Contingency plan/emergency response plan ☐ Readily available ☐ Up to date ☐ N/A
Remarks

3. **O&M and OSHA Training Records** ☐ Readily available ☐ Up to date ☐ N/A
Remarks

4. **Permits and Service Agreements**
☐ Air discharge permit ☐ Readily available ☐ Up to date ☒ N/A
☐ Effluent discharge ☐ Readily available ☐ Up to date ☐ N/A
☐ Waste disposal, POTW ☐ Readily available ☐ Up to date ☐ N/A
☐ Other permits ☐ Readily available ☐ Up to date ☐ N/A
Remarks

5. **Gas Generation Records** ☐ Readily available ☐ Up to date ☒ N/A
Remarks

6. **Settlement Monument Records** ☐ Readily available ☐ Up to date ☒ N/A
Remarks

7. **Groundwater Monitoring Records** ☒ Readily available ☒ Up to date ☐ N/A
Remarks last round of sampling 12/03

8. **Leachate Extraction Records** ☐ Readily available ☐ Up to date ☒ N/A
Remarks

9. **Discharge Compliance Records**
☐ Air ☐ Readily available ☐ Up to date ☒ N/A
☐ Water (effluent) ☐ Readily available ☐ Up to date ☒ N/A
Remarks

10. **Daily Access/Security Logs** ☐ Readily available ☐ Up to date ☒ N/A
Remarks

IV. O&M COSTS

1. **O&M Organization**
☐ State in-house ☐ Contractor for State
☐ PRP in-house ☒ Contractor for PRP
☐ Federal Facility in-house ☐ Contractor for Federal Facility
☐ Other

2. **O&M Cost Records**
☐ Readily available ☐ Up to date
☐ Funding mechanism/agreement in place
Original O&M cost estimate__________________ ☐ Breakdown attached

Total annual cost by year for review period if available

From________ Date	To________ Date	________ Total cost	☐ Breakdown attached
From________ Date	To________ Date	________ Total cost	☐ Breakdown attached
From________ Date	To________ Date	________ Total cost	☐ Breakdown attached
From________ Date	To________ Date	________ Total cost	☐ Breakdown attached
From________ Date	To________ Date	________ Total cost	☐ Breakdown attached

3. **Unanticipated or Unusually High O&M Costs During Review Period**
Describe costs and reasons: BioMonitoring performed by PRP was more expensive than one performed by NOAA

V. ACCESS AND INSTITUTIONAL CONTROLS ☒ Applicable ☐ N/A

A. Fencing

1. **Fencing damaged** ☐ Location shown on site map ☐ Gates secured ☐ N/A
Remarks________________________________

B. Other Access Restrictions

1. **Signs and other security measures** ☐ Location shown on site map ☐ N/A
Remarks Lock missing on gate for Zone E - former plant area

C. Institutional Controls (ICs)

1. **Implementation and enforcement**
Site conditions imply ICs not properly implemented ☐ Yes ☐ No ☒ N/A
Site conditions imply ICs not being fully enforced ☐ Yes ☐ No ☒ N/A

Type of monitoring (*e.g.*, self-reporting, drive by) ____
Frequency 1-2 per year
Responsible party/agency CRA
Contact Robert Bressan ____ ____ ____
Name Title Date Phone no.

Reporting is up-to-date ☐ Yes ☐ No ☒ N/A
Reports are verified by the lead agency ☐ Yes ☐ No ☒ N/A

Specific requirements in deed or decision documents have been met ☐ Yes ☒ No ☐ N/A
Violations have been reported ☐ Yes ☒ No ☐ N/A
Other problems or suggestions: ☐ Report attached

2. **Adequacy** ☒ ICs are adequate ☐ ICs are inadequate ☐ N/A
Remarks Deed Restriction have not been implemented / Recorded. However other ICs are adequate

D. General

1. **Vandalism/trespassing** ☐ Location shown on site map ☒ No vandalism evident
Remarks ____

2. **Land use changes on site** ☒ N/A
Remarks ____

3. **Land use changes off site** ☒ N/A
Remarks ____

VI. GENERAL SITE CONDITIONS

A. Roads ☒ Applicable ☐ N/A

1. **Roads damaged** ☐ Location shown on site map ☐ Roads adequate ☐ N/A
Remarks ____

B. Other Site Conditions

Remarks ____

____

____

____

____

____

VII. LANDFILL COVERS ☐ Applicable ☒ N/A

A. Landfill Surface

1. **Settlement** (Low spots) ☐ Location shown on site map ☐ Settlement not evident
Areal extent______________ Depth____________
Remarks____

____

2. **Cracks** ☐ Location shown on site map ☐ Cracking not evident
Lengths____________ Widths___________ Depths__________
Remarks____

____

3. **Erosion** ☐ Location shown on site map ☐ Erosion not evident
Areal extent______________ Depth____________
Remarks____

____

4. **Holes** ☐ Location shown on site map ☐ Holes not evident
Areal extent______________ Depth____________
Remarks____

____

5. **Vegetative Cover** ☐ Grass ☐ Cover properly established ☐ No signs of stress
☐ Trees/Shrubs (indicate size and locations on a diagram)
Remarks____

____

6. **Alternative Cover (armored rock, concrete, etc.)** ☐ N/A
Remarks____

____

7. **Bulges** ☐ Location shown on site map ☐ Bulges not evident
Areal extent______________ Height____________
Remarks____

____

8. **Wet Areas/Water Damage** ☐ Wet areas/water damage not evident
☐ Wet areas ☐ Location shown on site map Areal extent______________
☐ Ponding ☐ Location shown on site map Areal extent______________
☐ Seeps ☐ Location shown on site map Areal extent______________
☐ Soft subgrade ☐ Location shown on site map Areal extent______________
Remarks____

____

9.	**Slope Instability** ☐ Slides ☐ Location shown on site map ☐ No evidence of slope instability Areal extent______________ Remarks____	
B. Benches	☐ Applicable ☒ N/A (Horizontally constructed mounds of earth placed across a steep landfill side slope to interrupt the slope in order to slow down the velocity of surface runoff and intercept and convey the runoff to a lined channel.)	
1.	**Flows Bypass Bench** ☐ Location shown on site map ☐ N/A or okay Remarks____	
2.	**Bench Breached** ☐ Location shown on site map ☐ N/A or okay Remarks____	
3.	**Bench Overtopped** ☐ Location shown on site map ☐ N/A or okay Remarks____	
C. Letdown Channels	☐ Applicable ☒ N/A (Channel lined with erosion control mats, riprap, grout bags, or gabions that descend down the steep side slope of the cover and will allow the runoff water collected by the benches to move off of the landfill cover without creating erosion gullies.)	
1.	**Settlement** ☐ Location shown on site map ☐ No evidence of settlement Areal extent______________ Depth____________ Remarks____	
2.	**Material Degradation** ☐ Location shown on site map ☐ No evidence of degradation Material type______________ Areal extent____________ Remarks____	
3.	**Erosion** ☐ Location shown on site map ☐ No evidence of erosion Areal extent______________ Depth____________ Remarks____	
4.	**Undercutting** ☐ Location shown on site map ☐ No evidence of undercutting Areal extent______________ Depth____________ Remarks____	
5.	**Obstructions** Type____________________ ☐ No obstructions ☐ Location shown on site map Areal extent______________ Size____________ Remarks____	

6.	**Excessive Vegetative Growth** Type____________ ☐ No evidence of excessive growth ☐ Vegetation in channels does not obstruct flow ☐ Location shown on site map Areal extent__________ Remarks______________________________
D.	**Cover Penetrations** ☐ Applicable ☒ N/A	
1.	**Gas Vents** ☐ Active ☐ Passive ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition ☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A Remarks______________________________
2.	**Gas Monitoring Probes** ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition ☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A Remarks______________________________
3.	**Monitoring Wells** (within surface area of landfill) ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition ☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A Remarks______________________________
4.	**Leachate Extraction Wells** ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition ☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A Remarks______________________________
5.	**Settlement Monuments** ☐ Located ☐ Routinely surveyed ☐ N/A Remarks______________________________
E.	**Gas Collection and Treatment** ☐ Applicable ☒ N/A	
1.	**Gas Treatment Facilities** ☐ Flaring ☐ Thermal destruction ☐ Collection for reuse ☐ Good condition ☐ Needs Maintenance Remarks______________________________
2.	**Gas Collection Wells, Manifolds and Piping** ☐ Good condition ☐ Needs Maintenance Remarks______________________________
3.	**Gas Monitoring Facilities** (*e.g.*, gas monitoring of adjacent homes or buildings) ☐ Good condition ☐ Needs Maintenance ☐ N/A Remarks______________________________

F. Cover Drainage Layer		☐ Applicable	☒ N/A
1.	**Outlet Pipes Inspected** Remarks________________	☐ Functioning	☐ N/A
2.	**Outlet Rock Inspected** Remarks________________	☐ Functioning	☒ N/A
G. Detention/Sedimentation Ponds		☐ Applicable	☒ N/A
1.	**Siltation** Areal extent__________ Depth__________ ☐ Siltation not evident Remarks________________		☐ N/A
2.	**Erosion** Areal extent__________ Depth__________ ☐ Erosion not evident Remarks________________		
3.	**Outlet Works** Remarks________________	☐ Functioning	☐ N/A
4.	**Dam** Remarks________________	☐ Functioning	☐ N/A
H. Retaining Walls		☐ Applicable	☒ N/A
1.	**Deformations** Horizontal displacement__________ Vertical displacement__________ Rotational displacement__________ Remarks________________	☐ Location shown on site map	☐ Deformation not evident
2.	**Degradation** Remarks________________	☐ Location shown on site map	☐ Degradation not evident
I. Perimeter Ditches/Off-Site Discharge		☐ Applicable	☒ N/A
1.	**Siltation** Areal extent__________ Depth__________ Remarks________________	☐ Location shown on site map	☐ Siltation not evident
2.	**Vegetative Growth** ☐ Vegetation does not impede flow Areal extent__________ Type__________ Remarks________________	☐ Location shown on site map	☐ N/A

3.	**Erosion** ☐ Location shown on site map ☐ Erosion not evident Areal extent______________ Depth____________ Remarks____
4.	**Discharge Structure** ☐ Functioning ☐ N/A Remarks____
	VIII. VERTICAL BARRIER WALLS ☐ Applicable ☒ N/A
1.	**Settlement** ☐ Location shown on site map ☐ Settlement not evident Areal extent______________ Depth____________ Remarks____
2.	**Performance Monitoring** Type of monitoring__________________ ☐ Performance not monitored Frequency______________________ ☐ Evidence of breaching Head differential__________________ Remarks____
	IX. GROUNDWATER/SURFACE WATER REMEDIES ~~☒ Applicable~~ ~~☒ N/A~~
	A. Groundwater Extraction Wells, Pumps, and Pipelines ☐ Applicable ☒ N/A
1.	**Pumps, Wellhead Plumbing, and Electrical** ☐ Good condition ☐ All required wells properly operating ☐ Needs Maintenance ☐ N/A Remarks____
2.	**Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances** ☐ Good condition ☐ Needs Maintenance Remarks____
3.	**Spare Parts and Equipment** ☐ Readily available ☐ Good condition ☐ Requires upgrade ☐ Needs to be provided Remarks____
	B. Surface Water Collection Structures, Pumps, and Pipelines ☐ Applicable ☒ N/A
1.	**Collection Structures, Pumps, and Electrical** ☐ Good condition ☐ Needs Maintenance Remarks____
2.	**Surface Water Collection System Pipelines, Valves, Valve Boxes, and Other Appurtenances** ☐ Good condition ☐ Needs Maintenance Remarks____

3. **Spare Parts and Equipment**
☐ Readily available ☐ Good condition ☐ Requires upgrade ☐ Needs to be provided
Remarks____

C. Treatment System ☐ Applicable [X] N/A

1. **Treatment Train** (Check components that apply)
☐ Metals removal ☐ Oil/water separation ☐ Bioremediation
☐ Air stripping ☐ Carbon adsorbers
☐ Filters____
☐ Additive (*e.g.*, chelation agent, flocculent)____
☐ Others____
☐ Good condition ☐ Needs Maintenance
☐ Sampling ports properly marked and functional
☐ Sampling/maintenance log displayed and up to date
☐ Equipment properly identified
☐ Quantity of groundwater treated annually_____________________
☐ Quantity of surface water treated annually_____________________
Remarks____

2. **Electrical Enclosures and Panels** (properly rated and functional)
☐ N/A ☐ Good condition ☐ Needs Maintenance
Remarks____

3. **Tanks, Vaults, Storage Vessels**
☐ N/A ☐ Good condition ☐ Proper secondary containment ☐ Needs Maintenance
Remarks____

4. **Discharge Structure and Appurtenances**
☐ N/A ☐ Good condition ☐ Needs Maintenance
Remarks____

5. **Treatment Building(s)**
☐ N/A ☐ Good condition (esp. roof and doorways) ☐ Needs repair
☐ Chemicals and equipment properly stored
Remarks____

6. **Monitoring Wells** (pump and treatment remedy)
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
☐ All required wells located ☐ Needs Maintenance ☐ N/A
Remarks____

D. Monitoring Data

1. Monitoring Data
[X] Is routinely submitted on time ☐ Is of acceptable quality

2. Monitoring data suggests:
☐ Groundwater plume is effectively contained [X] Contaminant concentrations are declining

D. Monitored Natural Attenuation
1. **Monitoring Wells** (natural attenuation remedy) ☒ Properly secured/locked ☒ Functioning ☐ Routinely sampled ☒ Good condition ☒ All required wells located ☐ Needs Maintenance ☐ N/A Remarks

X. OTHER REMEDIES

If there are remedies applied at the site which are not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy. An example would be soil vapor extraction.

XI. OVERALL OBSERVATIONS

A. Implementation of the Remedy

Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission, etc.).

Southern Shoreline – Rockwall in good physical condition

ZONE B (Barren ZONE)
✓ good physical condition of rock wall
✓ vegetation growth.
Early spring season – not completely green

No erosion evidenced.

B. Adequacy of O&M

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.

C. Early Indicators of Potential Remedy Problems

Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs, that suggest that the protectiveness of the remedy may be compromised in the future.

D. Opportunities for Optimization

Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy.

STATE OF MICHIGAN
DEPARTMENT OF ENVIRONMENTAL QUALITY
LANSING

JENNIFER M. GRANHOLM
GOVERNOR

STEVEN E. CHESTER
DIRECTOR

July 29, 2004

Mr. Richard C. Karl
Acting Director, Superfund Division
United States Environmental Protection Agency
Region 5
77 West Jackson Boulevard (SR-6J)
Chicago, Illinois 60604

Dear Mr. Karl:

SUBJECT: Comments on the Draft Five-Year Review Report for the Cannelton Industries Superfund Site, Chippewa County, Michigan

Thank you for the opportunity to review and comment on the draft Five-Year Review Report (Review) for the Cannelton Industries Superfund site dated July 12, 2004, as well as earlier drafts. The Michigan Department of Environmental Quality (MDEQ) has completed its review and provides the following comments:

Sediments

We have reviewed all of the sediment investigation data for this site and summarize our findings on the various study types below.

Toxic and Bioaccumulative Characteristics: On page 19, the third paragraph, the Review states, "The results for sediment toxicity and bioaccumulation studies indicated that the sediments did not pose a significant threat to aquatic organisms due to chemical concentrations in soils and sediments in Tannery Bay." Yet, on page 35 the Review states, "There has not been sufficient data collected to make the determination for long-term protectiveness for the remedy selected in Tannery Bay." Perhaps some of the apparent disparity in evaluations derives from an attempt to distinguish between long and short term risks. If so, this could perhaps be clarified. The Remediation and Redevelopment Division (RRD) finds that the site's toxicity work on the sediments showed some indications of site-related toxicity, but the trends were of indeterminate significance, perhaps as much due to the small study size and limited statistical power of the studies, as to a lack of marked toxicity. Our evaluation of these toxicity studies is briefly summarized in our April 8, 2004, letter supporting use of Great Lakes Legacy (GLL) funding for sediment removal at this site.

Both of the bioaccumulation studies conducted to date were also indeterminate in light of mercury contamination of the initial study outset mussel tissues, as you note in the Review on page 26.

Geochemical Stability: Page 21 offers a very good discussion of the attempts by the potentially responsible parties (PRP) to characterize the stability of the organic/metal bonds which render the high metals concentrations nominally bioavailable. It mentions the relevance of the soil studies to the sediments. These discussions mention the shortcomings of not studying the effects of potential exposure to oxygen such as through erosion and other disturbances, and not studying the effects of exhausting the buffering capacity of the matrix.

Erosive Stability: On page 21 of the Review, second to last paragraph, it states that "...the potential for significant re-suspension of sediments is very low." However, our review of the storm erosion analysis indicated that in a 50-year storm event as much as 200 cubic yards of sediments might be eroded from the bay. The phenomenon of ice scouring as acknowledged in the 1996 Record of Decision (ROD) amendment should also be considered in evaluations of the protectiveness of the sediment remedy. One form of ice scouring which has not been mentioned but was observed by John Shauver, MDEQ, is that whereby the winter freeze extends through the ice and into the sediments, and then the high water of the spring melt carries these frozen sediments into the river in the form of ice floes. Granted, neither agency has quantitative criteria for acceptable erosion limits, but the RRD finds the erosive stability of the sediments to be questionable.

All the above factors need to be considered in the weight of evidence evaluation on the protectiveness of the sediment remedy. For purposes of the present Review we recommend language expressing continuing questions as to protectiveness of the sediment remedy. These questions could in part be answered by the planned 2005 mussel bioaccumulation study, or they could be obviated by the contemplated GLL removal. Our present leaning is toward an evaluation that the sediment remedy is not protective in the short or long term, which is why we have so strongly advocated their removal from the river, and offered cost-share monies for the GLL project.

Wetlands

The 1996 amended ROD calls for "...surface water, groundwater, sediment, wetland soils, and biological monitoring, including bioavailability studies for metals of concern (chromium, cadmium, mercury, arsenic, and lead)." While bioavailability studies are being done for sediments, they have yet to be done for wetland soils.

We also have some concerns about the metals exceedances in the last wetland pond monitoring round. It does seem likely they are attributable to the faulty sampling methods, but we will need to repeat the monitoring. All things considered, the RRD finds the need to recommend language being inserted in the Review that the protectiveness of the remedy for the wetlands remains uncertain.

The proposed GLL remedy calls for removal of wetland soils with high concentrations of mercury and chromium. If this proposal were to be carried out as planned it would largely obviate the need for bioavailability studies in the wetlands, but if it is not carried out the RRD recommends immediately pursuing bioavailability studies for wetland soils.

Current Status – Zones A, B, E

We recommend the fourth complete sentence be rewritten to read: "However, concurrence has been delayed pending a response from the PRP with their assertion that the site meets MDEQ land use closure criteria and related administrative requirements for closure." Similar wording would be appropriate on page 30, under Section VII - Technical Assessment, Question A.

If you have any questions regarding these comments, please contact Mr. Bruce VanOtteren at 517-373-8427, or you may contact me.

Sincerely,

AWHogarth

Andrew W. Hogarth, Chief
Remediation and Redevelopment Division
517-335-1104

cc: √Ms. Rosita Clarke-Moreno, United States Environmental Protection Agency
Ms. Elizabeth M. Browne, MDEQ
Ms. Daria W. Devantier, MDEQ
Mr. Bruce VanOtteren, MDEQ/Cannelton File (O1)

U.S. Environmental Protection Agency
Region 5

Cannelton Inc. Superfund Site
Sault Ste. Marie, Mich.

Public Meeting and Availability Session
October 23, 2002

EPA will hold a public meeting followed by an availability session to discuss a proposed partial delisting and plans for the five-year review of the Cannelton Inc. Superfund Site. Representatives from the City of Sault Ste. Marie and the Michigan Department of Environmental Quality also will make presentations at the public meeting . Potential future uses of the Site and redevelopment will also be discussed. The availability session will allow people to discuss specific concerns. Representatives from Phelps Dodge, current property owner, will also be present to answer questions and for the availability session.

Public Meeting
5:30 - 6:30 p.m.

Availability Session
6:30 - 8 p.m.

Lincoln Elementary School
810 E 5th Ave.
Sault Ste Marie, Mich.

More information:

Rosita Clarke-Moreno
U.S. EPA Superfund Division (SF-6J)
77 West Jackson Blvd.
Chicago, IL 60604
(312) 886-7251
clarke.rosita@epa.gov

United States Environmental Protection Agency
Region 5
77 West Jackson Blvd.
Chicago, Illinois 60604
Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin

EPA **Environmental**
NEWS RELEASE

CONTACT: Don de Blasio, (312) 886-4360
Rosita Clarke-Moreno, (312) 886-7251

FOR IMMEDIATE RELEASE No. 02-OPA XXX

EPA HOLDS MEETING ON CANNELTON SUPERFUND SITE PROGRESS AND RE-USE, OCT. 23, 5:30 P.M.

CHICAGO (Oct. 17, 2002) — U.S. Environmental Protection Agency Region 5 will hold a public meeting followed by an availability session to discuss issues related to the completed cleanup and potential re-uses of the Cannelton, Inc., Superfund site, in Sault Ste. Marie, Mich., Wed. Oct. 23, at Lincoln Elementary School, 810 East 5th Ave.

The public meeting begins at 5:30 and includes presentations by EPA, Michigan Department of Environmental Quality and the city of Sault Ste. Marie. An informal availability session begins at 6:30, allowing residents to discuss specific concerns with officials one-on-one. Representatives from Phelps Dodge, the current site owner, will also be available.

The Cannelton cleanup, completed in October 1999, included the excavation and off-site disposal of 33,000 tons of contaminated soils and tannery waste, as well as efforts to landscape and stabilize portions of the St. Marys River shoreline.

# # #

U.S. Environmental Protection Agency
Region 5
Cannelton Industries Inc. Superfund Site
Public Meeting / Availability Session
Sault Ste. Marie, MI
October 23, 2002

AGENDA

` Introductions	Don de Blasio Community Involvement Coordinator, EPA
` Site Update/Partial Delisting Plans	Rosita Clarke-Moreno Project Manager, EPA
` State Involvement	Bruce Van Otteren Michigan Department of Environmental Quality
` City Involvement and Development Plans	City Officials
` Potentially Responsible Parties Activities	Company Representatives
` Question/Answer Session	Audience/Participants

Availability Session

Adjourn: 8 p.m.

notes

United States Environmental Protection Agency
Region 5
77 West Jackson Boulevard
Chicago, IL 60604
Illinois, Indiana
Michigan, Minnesota
Ohio, Wisconsin

EPA

Partial Delisting Proposed
5-year Review Plan to Be Developed

Cannelton Industries Inc. Superfund Site

Sault Ste. Marie, Mich. October 2002

The U.S. Environmental Protection Agency, is proposing to delist some parts of the Cannelton Industries Inc. Superfund Site, in Sault Ste. Marie, Michigan. EPA is also beginning to develop its five-year review of the cleanup carried out at the site.

Cannelton completed cleanup activities at the site in October of 1999. Cleanup activities included excavation and off-site disposal of 33,000 tons of contaminated soils and tannery- waste materials from the Barren Zone (Zone B), Western Shoreline (Zone A) and the Southern Shoreline of the Tannery Bay. Waste was disposed at 2 permitted off-site solid waste facilities. Cleanup activities also included regrading and landscaping of the western shoreline, backfilling and regrading as needed in the Barren Zone; seeding and mulching to revegetate the Western Shoreline and Barren Zone. Cannelton also constructed a stabilization berm to protect the shoreline from further erosion.

After two years of monitoring, EPA in consultation with MDEQ, has determined that cleanup goals for soils and groundwater have been met. This makes certain areas of the site eligible for removal from the National Priorities List, a list of nearly 1,300 Superfund sites nationwide. The eligible areas are Zones A, B, and E on the map.

How Sites are Delisted from NPL

EPA may delist an NPL site if it determines that no further response is needed to protect human health or the environment. A site may be delisted where no further response is appropriate if EPA determines that one of the following criteria has been met:

- EPA, in conjunction with the State, has determined that responsible or other parties have implemented all appropriate response action required
- EPA, in consultation with the State, has determined that all appropriate Superfund-financed responses under CERCLA have been carried out and that no further response by responsible parties is appropriate
- a remedial investigation has shown that the release poses no significant threat to public health or the environment and remedial measures are not appropriate.

Re Use and Future Redevelopment

The Cannelton Site sits in an area zoned for industrial use. The clean-up activities at the Site allows the site to be utilized for industrial uses and meets industrial standards. Others parts of the site meets residential and recreational standards. The City of Sault Ste. Marie is exploring with the current owner of the property about acquisition of the property and planning potential reuses for the Site.

Meeting
October 23, 2002 at

Lincoln Elementary School, 810 East 5th Ave. 5:30 - 8:00pm. Representatives from agencies will be available from 6:30-8:00pm to answer questions.

Additional Information

If you have questions about the **Cannelton Industries Inc. Site,** or would like to be added to the mailing list, please contact:

Don DeBlasio
Community Involvement Coordinator
(312) 886-4360 or
(800) 621-8431
deblasio.don@epa.gov

Rosita Clarke-Moreno
Project Manager
(312)886-7251
clarke.rosita@epa.gov

More information on the Site can be found at:

Bayliss Public Library
541 Library Drive
Sault Ste. Marie, Michigan 49783
(906)632-9331

A copy of this fact sheet and others can be downloaded from the EPA Region 5 web site at: http://www.epa.gov/region5/sites

The Five-Year Review

The Superfund regulation requires a five-year review of all sites where, upon completion of cleanup, levels of contaminants remain above the health-based levels that allow for unrestricted use of a site. The five-year review process is used to ensure that the selected remedy continues to be protective of human health and the environment. EPA is starting its planning now for the Cannelton site, which will have its five-year review completed in June 2004.

How the Community can Participate

EPA will have a 30-day public comment period that will commence when the partial delisting is noticed on the Federal Register (FR). The Federal Register Notice will have information on where you can send your comments.

EPA invites the community to participate in the **Five-Year Review** process by providing comments and concerns regarding the clean-up at the Cannelton Industries Site and any related concerns regarding the site. These comments and concerns can be directed to the EPA Remedial Project Manager, Rosita Clarke-Moreno or other contacts for the Site.

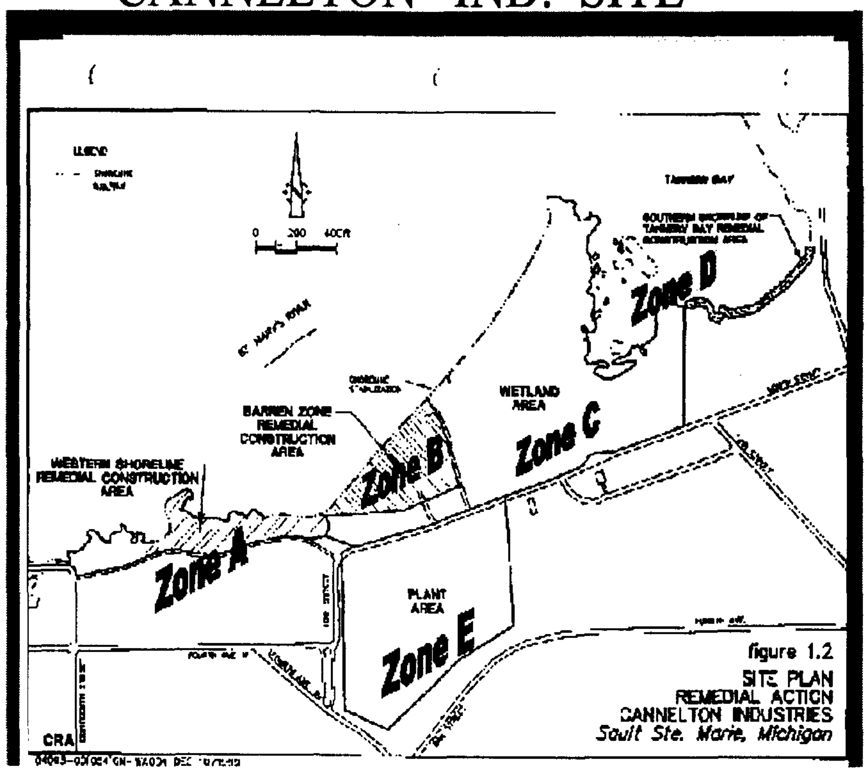
Site Background

The Cannelton site is on the shore the St. Marys River, about one mile upstream of the Soo Locks and 1½ miles west of downtown Sault Ste. Marie.

The Northwestern Leather Co. operated a tannery on the property from 1900 to 1958. The company process raw animal hides to form finished leather. In 1958, the tannery closed and the property was sold. The tannery plant was destroyed by fire later that year. The only sewage disposal system the plant had was three drains consisting of pipes and open ditches. The drains ran north to the shore of the St. Marys River, where tannery wastes were discharged.

EPA began investigations at the site in 1989, with an original clean-up plan in 1992. After pre-design studies were completed, a revised clean-up plan - Record of Decision Amendment - was completed in 1996. The engineering design for the plan was completed in December of 1998 and construction activities were implemented in the summer of 1999.

CANNELTON IND. SITE



Rosita Clarke/R5/USEPA/US
05/12/2004 10:16 AM

To

Subject Cannelton Industries Inc. Site, Five Year Review

Hello, U.S. EPA is currently conducting the Five Year Review for the Cannelton Industries Site and I plan on travelling to the Site the week of June 7th, 2004. I would like to meet with you (in groups or individually) to discuss the site and obtain your input regarding the Site's progress and the protectiveness of the remedy. At this time I can provide a status of activities and we can discuss and questions or concerns you may have.

Under CERCLA, Five Year Reviews are to evaluate the remedy implemented at sites and evaluate the effectiveness and protectiveness of that remedy. Community and Stakeholder interest is important to this process.

Please let me know (phone or email) your availability if you'd like to meet with me, for the days of June 7 - 9th.

I'd appreciate your response asap, so that I can appropriately plan my itenerary. I look forward to meeting each of you in person and discussiing the Cannelton Site.

Thank You.
Rosita Clarke-Moreno
U.S. EPA - Superfund
77 West Jackson Blvd (SR-6J)
Chicago, IL 60604
(312)886-7251
FAX (312)886-4071

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, ILLINOIS 60604

SR-6J

May 26, 2004

Re: Cannelton Industries, Inc. Superfund Site

Dear Resident/Community Member:

The U.S. Environmental Protection Agency (EPA) would like to provide you with a status of activities at the Cannelton Site.

Since 1999, when clean-up activities were completed, the property owner with oversight from EPA and Michigan Department of Environmental Quality (MDEQ) has been implementing the Long-Term Monitoring Plan at the site. Long term monitoring of the site include surface water and sediment sampling along Tannery Bay to ensure that remedy remains protective of human health and the environment. Results of the latest sampling, conducted in December of 2003, show no changes in chemical concentrations in surface water and sediments. Groundwater results show that no future groundwater sampling is necessary since clean-up goals have been met for groundwater, and this portion of the monitoring will be discontinued.

In October of 2002, U.S. EPA provided a Site update and presented to the community 3 ongoing activities for the site, in addition to the monitoring events: (a) EPA's proposal to delete 3 areas of the Site from the NPL; (b) City's proposal for future redevelopment of these future NPL delisted areas; and (c) the upcoming Five Year Review for the Site.

Status of these 3 activities:

(a) EPA's proposal for delisting areas of the site is still in process, some delays have occurred, but issues needing resolution for this to be accomplished, are being worked on by the property owner, MDEQ and EPA.
(b) The City's intent for future redevelopment and reuse of these areas are still on the table and will move forward once the first item (a) above is resolved.
(c) EPA is finalizing the Five Year Review and should complete this Report by mid-late June. A copy of the Report will be made available to the Community via EPA's website **http://www.epa.gov/region5/superfund/fiveyear/fyr_index.html**. A copy of the full report will also be available at the Bayliss Public Library, 541 Library Dr., Sault Ste. Marie, MI 49783 (906) 632-9331.

Five Year Reviews are conducted at Sites to ensure that the remedy implemented remains protective of human health and the environment. All past clean-up information for the site and any new relevant information is evaluated to ensure protectiveness. The community's input in this process was requested in October 2002, and any comments, questions or concerns are still welcome. If you'd like to provide input to EPA, please contact me, Rosita Clarke-Moreno, Project Manager for the Cannelton Site at (312)886-7251 or 800-621-8431. Email **clarke.rosita@epa.gov**.

Sincerely,

R Clarke Moreno

Appendix E
Literature Review of Metal Cycling by Cattails

Literature Review of Metal Cycling by Cattails

Prepared by
NOAA Coastal Protection and Restoration Division,
July 2004

Metal contamination of sediment and water frequently occurs at sites around the Great Lakes. The bioavailability and toxicity of various metals have been well studied for a variety of organisms. The Cannelton Industries Superfund Site contains a thick stand of cattails along the western shore of Tannery Bay and in the adjacent wetland area. These cattails have been encroaching on the Bay over time. While this is a natural phenomenon, its potential impact on the Site must be evaluated as a part of the 5-year review.

Typha spp.

Typha spp., commonly known as cattails, are distributed throughout North America. This genus is found in fresh water areas such as meadows, marshes, fens, ponds, lakes, rivers, and streams, but can also be found in slightly brackish marshes. Cattails are generally tolerant of continuous inundation and seasonal drawdowns, but prefer shallow water habitats.

Cattails can form dense, single species stands and floating mats. Each individual plant can spread extensively by rhizomes so that an acre of cattails may consist of only a few individuals. However, they also can occur in mixed stands with Bulrush (*Scirpus acutus*, *S. californicus*) and Maidencane (*Panicum hemitomon*). *Typha spp.* is often found down slope of the Common Reed (*Phragmites australis*), Reed Canarygrass (*Phalaris arundinacea*), and willows (*Salix* spp.). *Typha* spp. is a dominant component of early successional stages in wetlands. This is most likely due to its ability to rapidly colonize an area via wind and water dispersed seeds.

Benefits

The addition of vascular plants can stabilize sediments and prevent erosion by reducing the surface water inflow. Cattails can minimize sediment resuspension and maximize the potential for recolonization (Wong 2003). The physical structure of cattails can also provide shade and shelter habitat for fish.

Biotoxicity can be reduced when wetland plants alter the metal form, in turn altering the metal bioavailability. Perhaps most importantly, wetlands can reduce Pb by 94%, Mn by 44%, Ni by 84%, Fe by 84%, and dissolved Cd, Cr, Cu and Zn by 98% (EPA 1992). Vascular plants can also accumulate Hg and B from sediments and water.

Concerns

One concern with cattail proliferation at the Site is the potential for metals the cattails to extract metals from the system and then redistribute them. Seasonal cycles could be responsible for spreading the metals much farther than they had originally been distributed. In the fall, leaves of cattails senesce and can contribute significant quantities of organic matter via throughfall and litterfall. As a result, cattail stands tend to grow on sediments with high concentrations of organic matter in the surface layers.

Uptake

Typha spp. can accumulate mercury from sediment, porewater, water, and air. Uptake in aquatic plants has been correlated with the concentration of mercury in the water (Lenka et al. 1990; Windom and Kendall. 1979). In aqueous laboratory experiments, 43.7 – 54.1% of mercury was removed by *Typha* (Krishnan et al. 1988). Similarly, Robichaud et al. (1995) found that common cattail (*Typha latifolia*), burr reed (*Sparganium minimum*), and *Menyanthes trifoliata* roots readily absorb mercury from aqueous solutions. Furthermore, the hydrophilic parts of the roots accumulated significantly more mercury than did the hydrophobic parts (Robichaud et al. 1995).

Foliar uptake of metals by C3 species (e.g. *Typha* spp.) can be five times greater than that of C4 species (e.g. other wetland species) (Patra and Sharma 2000). Metal uptake rates can vary depending on the metal and tissue type. Vascular plants accumulate both inorganic and methylmercury from sediment and water in root, stem, and leaf sections (Alberts et al. 1990; Boudou et al. 1991). Metal uptake of Pb and Hg in dried roots of *Typha* were 42 and 76 mg/g-hr, respectively (Robichaud 1996). Metal uptake of Zn, Cu, Pb, and Cd in shoots of *Typha* were 85, 11, 0.2, and 2.2 mg/m^2, respectively (Dunbabin and Bowmer 1992).

Factors Affecting Uptake

Factors affecting plant uptake include the size, duration, and timing of contamination; oxide and carbonate content; redox potential; sediment organic carbon; and oxygen content.

Breteler et al. (1981) examined factors which would affect the uptake of mercury by *S. alterniflora*. They found that redox potential was not a significant influence for mercury at this site. However, Davies and Jones (1988) determined that redox potential is a significant influence on iron uptake since it dictates the solubility of iron in soil. Zn is more available at higher Eh (Davies and Jones 1988).

Other factors such as pH and organic matter can affect uptake. Mn availability and toxicity are often affected by pH since Mn is more available at low pH (acidic) environments(Davies and Jones 1988). Cu is more readily complexed (and less available) in soils with high organic matter content and/or acidic environments(Davies and Jones 1988). Additionally, Breteler et al. (1981) demonstrated that roots more readily accumulated mercury in soils with lower organic matter.

Partitioning

A summary of *Typha* uptake concentrations is presented in Table 1. Most research (Cardwell et al. 2002; Debusk et al. 1996; Mays and Edwards 2001; Sriyaraj and Shutes 2001; Ye et al. 1997), indicates that metal concentrations follow the general order roots > rhizomes > shoots/leaves. However, when shoots were divided into subcategories metals were fractioned in the following order: roots > rhizomes > mature fruit > shoot tip > shoot midsection > shoot base (Taylor and Crowder 1983). The ability of vascular plants to transfer metals varies depending on the species. For example,*Juncus effusus* transfers metals to stems much more efficiently than *Typha latifolia* (Shutes et al. 1993).

Some evidence suggests that sediment concentrations do increase coinciding with the senescence of cattail stands. In other words, when cattails drop their leaves, sediment concentrations are elevated. Throughfall and litterfall have been shown to play a significant role in the cycling and deposition of mercury in the watershed of Lake Champlain (Rea et al. 1996). However, it is important to consider that the concentrations of metals in leaves are often an order of magnitude less than those in roots (Mays and Edwards 2001). Therefore, limited ability to transfer metals within the plant will ultimately dictate the concentration of metals that are reintroduced to the system due to litterfall. The shoot and leaf tissue concentrations are dependent upon several factors including the potential binding of the metal to the root surface, the transport of the metal into the root, and the metal translocation from the root to the shoot (Chaney and Giordano 1977; Wild 1988).

Toxicity

Overall, *Typha* sp. are very tolerant of metal-rich environments (Wong 2003). Tolerance is usually specific to one particular metal; however, *Typha* seems to be tolerant to a wide variety of individual metals and their mixtures. This tolerance, despite the uptake of metals, indicates that there are no observable adverse affects (Wong 2003). Lim et al. (2003) observed that metal uptake could lead to a potential inhibition of nitrogen uptake. Specifically, Lim et al. found that increased metal loadings (Zn, Pb, and Cd) decreased the ammoniacal nitrogen removal efficiency of the cattails.

There are a number of potential mechanisms that would prevent metal toxicity to cattails. Phytochelatins in plants and fungi prevent toxicity by binding the metal so that it is no longer bioavailable. Cattails may also sequester the metals by compartmentalizing the toxic compounds (Patra 2000). Regardless of the mechanism, the tolerance of *Typha* to metals allows it to flourish in an environment that may be toxic to other species.

Biomass

T. latifolia in a constructed wetland may take about two years to reach maximum biomass (Groudeva et al. 2001). An average biomass estimate for roots, rhizomes, and leaves was 60.4, 1077.6, and 838.1 g/m^2, respectively (Zhang et al. 1990). Seasonal variations in biomass can be indicative of high productivity.

Metal uptake in cattails is impressive based on tissue concentrations alone, but when normalized for biomass, the metals only account for 1-2% of the total metal loadings. It seems that while cattails do have the ability to uptake metals, their total impact on a site may be low due to low biomass in relation to the mass of the contaminated sediment.

Metals

Arsenic

Mays and Edwards (2001) performed an arsenic uptake study with *T. latifolia* in natural wetlands (Table 1). There were no significant differences between uptake in the spring versus that in the fall. Arsenic concentrations in roots and shoots were relatively low (3.9-8.6 and 0.03-0.06 ug/g, respectively) in wetlands with low aqueous arsenic concentrations (<0.4 - 0.85 ug/L) and sediment (1.43 – 3.44 ug/g). However, in natural wetlands with elevated arsenic concentrations in water (100 ug/L) and sediment (7.5 – 32 ug/g), root and shoot concentrations were higher (21.1 – 28.8 and 0.7 – 1 ug/g, respectively).

Cadmium

Cadmium uptake appears to be variable. In a study by Mays and Edwards (2001), Cd concentrations in water and sediment were below detection limits; however, root concentrations ranged from 1.7 to 6 ug/g. Ye et al. (1997) found that Cd concentrations were much more variable in roots than in shoots. In a system with Cd sediment concentrations ranging from 1.4 to 26 ug/g, root concentrations varied from 1 to 17 ug/g, however shoot concentrations were much less variable (ranging from 0.2 to 0.8 ug/g). This indicates that the variability in Cd concentrations may be due to unequal binding to roots. However, in a natural wetland and greenhouse study by Zhang et al. (1990), the rhizome Cd fraction exceeded that in roots and shoots.

Chromium

Mays and Edwards (2001) have illustrated seasonal variability in Cr uptake. In both constructed and natural wetlands, Cr concentrations were much higher in the spring than the fall (13-37 and 2.3 – 3.9 ug/g, respectively). Shoot concentrations demonstrated the same order of magnitude decrease in fall versus the spring.

Lead

In some natural wetlands, rhizomes have higher concentrations than both roots and shoots (Zhang et al. 1990, Ye et al. 1997). Since rhizomes have much more biomass than roots, this indicates that more Pb could be extracted than other metals which tend to partition to the roots. In a study of natural wetlands by Ye et al. (1997), root Pb concentrations (25 to 3628 ug/g) increased with increasing sediment Pb concentrations (26 to 18,894 ug/g).

Mercury

Mercury uptake and toxicity is highly influenced by its form/speciation. Methyl mercury is produced by bacterial decomposition of elemental or inorganic mercury. Higher sediment organic carbon content can increase microbial production, which would decrease available O_2, increasing the methylation rate of mercury (Beckvar et al. 1996). Breteler et al. (1981)demonstrated that an increased mercury methylation rate decreased the mercury uptake rate in *Spartina.* Organic mercury has been reported to be 200 times more potent than inorganic mercury. This form is so toxic because mercuric cations bind to sulphydryl (-SH) groups which can be found in almost all proteins (Clarkson 1972). Methylmercury can biomagnify up a food chain, which means that even small concentrations of methyl mercury in Typha could pose a serious threat to higher trophic levels (Meagher and Rugh 1997).

The fraction of mercury retained in the roots is about 20 times that observed in the shoots and is closely related to the NH_4OAc-extractable mercury in the soils (Lindberg et al., 1979). Patra and Sharma (2000) explained that there is a tendency for mercury to accumulate in roots, indicating that the roots serve as a barrier to mercury uptake. They further state that the mercury concentrations in aboveground plant tissues appear to depend on foliar uptake of mercury that has volatilized from the soil. Mercury concentrations in the plants (stems and leaves) are always greater when the metal is introduced in organic form (Patra and Sharma 2000).

Conclusion

Metals can be taken up by *Typha* directly from sediment, porewater, surface water, and air. In cattails, metals tend to follow similar partitioning patterns; roots tend to have the greatest metal concentration followed by rhizomes, then, shoots and leaves, respectively. While roots do extract a significant metal fraction, the relatively smaller biomass of the roots (vs. leaves and the contaminated sediment) limits the extraction impact on the contaminated site. Limited transfer of metals from the cattail roots also limits the potential for metal redistribution via leaf senescence or animal dissemination.

Table 1. Metal uptake in roots, rhizomes, and shoots of common cattails (NR= not reported, n.d. = not detected)

Paper	Species	Type of test	Contaminant	Metal	Water Concentration (ug/l)	Surface Sediment Concentration (ug/g)	Root Concentration (ug/g)	Rhizome Concentration (ug/g)	Shoot Concentration (ug/g)
Cardwell et al. 2002	*Typha orientalis*	Field natural wetland	Pb, Zn, Cu, Cd mixture	Cd	NR	0.03	0.13	NR	0.17
Cardwell et al. 2002	*Typha domingensis*	Field natural wetland	Pb, Zn, Cu, Cd mixture	Cd	NR	0.07 - 1.53	1.47 - 2.57	NR	n.d. - 0.20
Cardwell et al. 2002	*Typha domingensis*	Field natural wetland	Pb, Zn, Cu, Cd mixture	Cu	NR	17.6 - 38.3	53.5-127.4	NR	3.37 - 14.9
Cardwell et al. 2002	*Typha orientalis*	Field natural wetland	Pb, Zn, Cu, Cd mixture	Cu	NR	5.1	4.1	NR	2.37
Cardwell et al. 2002	*Typha orientalis*	Field natural wetland	Pb, Zn, Cu, Cd mixture	Pb	NR	14.9	0.2	NR	0.07
Cardwell et al. 2002	*Typha domingensis*	Field natural wetland	Pb, Zn, Cu, Cd mixture	Pb	NR	12.9 - 77.2	21.1 - 201.6	NR	1.57-4.53
Cardwell et al. 2002	*Typha domingensis*	Field natural wetland	Pb, Zn, Cu, Cd mixture	Zn	NR	93.4 - 514.1	355.5 - 1030	NR	21.4 - 83.4
Cardwell et al. 2002	*Typha orientalis*	Field natural wetland	Pb, Zn, Cu, Cd mixture	Zn	NR	29.7	13.3	NR	20.2

Paper	Species	Type of test	Contaminant	Metal	Water Concentration (ug/l)	Surface Sediment Concentration (ug/g)	Root Concentration (ug/g)	Rhizome Concentration (ug/g)	Shoot Concentration (ug/g)
Debusk et al. 1996	*Typha domingensis*	14 month microcosm	leachate, spiked with 396 ug/L Pb and 105 ug/L Cd	Cd	52	42-61	600	55	5.25
Debusk et al. 1996	*Typha domingensis*	14 month microcosm	leachate, spiked with 396 ug/L Pb and 105 ug/L Cd	Pb	196	198-295	1200	150	90
Mays and Edwards 2001	*Typha latifolia*	Field natural wetlands - Spring	Metals	As	< 0.4	1.43	3.9	NR	0.03
Mays and Edwards 2001	*Typha latifolia*	Field natural wetlands - Fall	Metals	As	< 0.4	1.47	8.6	NR	0.06
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (IMP)-Spring	Metals	As	0.85	3.2	3.5	NR	0.06
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (IMP) - Fall	Metals	As	0.85	3.44	3.8	NR	0.04
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (WC)-Spring	Metals	As	100	32	28.8	NR	0.07
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (WC)-Fall	Metals	As	100	7.5	21.1	NR	1

Paper	Species	Type of test	Contaminant	Metal	Water Concentration (ug/l)	Surface Sediment Concentration (ug/g)	Root Concentration (ug/g)	Rhizome Concentration (ug/g)	Shoot Concentration (ug/g)
Mays and Edwards 2001	*Typha latifolia*	Field natural wetlands - Spring	Metals	Cd	< 6	< 0.006	1.7	NR	< 0.006
Mays and Edwards 2001	*Typha latifolia*	Field natural wetlands - Fall	Metals	Cd	< 6	< 0.006	2.2	NR	0.06
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (IMP)-Spring	Metals	Cd	< 6	< 0.006	2.7	NR	< 0.006
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (IMP) - Fall	Metals	Cd	< 6	< 0.006	6	NR	0.1
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (WC)-Spring	Metals	Cd	20	< 0.006	2.4	NR	< 0.006
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (WC)-Fall	Metals	Cd	20	< 0.006	5.6	NR	0.4
Mays and Edwards 2001	*Typha latifolia*	Field natural wetlands - Spring	Metals	Cr	< 0.005	< 0.005	13	NR	3.3
Mays and Edwards 2001	*Typha latifolia*	Field natural wetlands - Fall	Metals	Cr	< 0.005	0.53	3.9	NR	0.7

Paper	Species	Type of test	Contaminant	Metal	Water Concentration (ug/l)	Surface Sediment Concentration (ug/g)	Root Concentration (ug/g)	Rhizome Concentration (ug/g)	Shoot Concentration (ug/g)
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (IMP)-Spring	Metals	Cr	< 0.005	< 0.005	37	NR	12
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (IMP) - Fall	Metals	Cr	< 0.005	0.78	3.1	NR	0.4
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (WC)-Spring	Metals	Cr	< 0.005	< 0.005	24	NR	6.2
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (WC)-Fall	Metals	Cr	< 0.005	0.38	2.3	NR	0.5
Mays and Edwards 2001	*Typha latifolia*	Field natural wetlands - Spring	Metals	Cu	NR	0.9	6.5	NR	6.3
Mays and Edwards 2001	*Typha latifolia*	Field natural wetlands - Fall	Metals	Cu	NR	1.13	5.4	NR	1.8
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (IMP)-Spring	Metals	Cu	NR	0.49	6.5	NR	1.2

Paper	Species	Type of test	Contaminant	Metal	Water Concentration (ug/l)	Surface Sediment Concentration (ug/g)	Root Concentration (ug/g)	Rhizome Concentration (ug/g)	Shoot Concentration (ug/g)
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (IMP) - Fall	Metals	Cu	NR	1.22	1.2	NR	1
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (WC)- Spring	Metals	Cu	NR	1.3	3.3	NR	3.6
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (WC)- Fall	Metals	Cu	NR	1.22	4.1	NR	2.5
Mays and Edwards 2001	*Typha latifolia*	Field natural wetlands - Spring	Metals	Fe	1.29	314	8820	NR	363
Mays and Edwards 2001	*Typha latifolia*	Field natural wetlands - Fall	Metals	Fe	1.29	372	9121	NR	253
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (IMP)- Spring	Metals	Fe	44	350	7427	NR	349
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (IMP) - Fall	Metals	Fe	44	448	28660	NR	327

Paper	Species	Type of test	Contaminant	Metal	Water Concentration (ug/l)	Surface Sediment Concentration (ug/g)	Root Concentration (ug/g)	Rhizome Concentration (ug/g)	Shoot Concentration (ug/g)
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (WC)-Spring	Metals	Fe	205	240	13077	NR	381
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (WC)-Fall	Metals	Fe	205	217	27322	NR	1739
Mays and Edwards 2001	*Typha latifolia*	Field natural wetlands - Spring	Metals	Mn	0.2	66	442	NR	751
Mays and Edwards 2001	*Typha latifolia*	Field natural wetlands - Fall	Metals	Mn	0.2	56	617	NR	821
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (IMP)-Spring	Metals	Mn	5.9	241	1786	NR	1752
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (IMP) - Fall	Metals	Mn	5.9	277	2012	NR	2076
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (WC)-Spring	Metals	Mn	7.4	123	121	NR	527

Paper	Species	Type of test	Contaminant	Metal	Water Concentration (ug/l)	Surface Sediment Concentration (ug/g)	Root Concentration (ug/g)	Rhizome Concentration (ug/g)	Shoot Concentration (ug/g)
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (WC)-Fall	Metals	Mn	7.4	59	144	NR	549
Mays and Edwards 2001	*Typha latifolia*	Field natural wetlands - Spring	Metals	Ni	< 0.029	0.85	8.5	NR	2.9
Mays and Edwards 2001	*Typha latifolia*	Field natural wetlands - Fall	Metals	Ni	< 0.029	0.73	4	NR	1.2
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (IMP)-Spring	Metals	Ni	< 0.029	< 0.03	18.1	NR	6.2
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (IMP) - Fall	Metals	Ni	< 0.029	0.96	1.5	NR	0.7
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (WC)-Spring	Metals	Ni	< 0.029	0.69	10.7	NR	3.3
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (WC)-Fall	Metals	Ni	< 0.029	0.9	0.5	NR	0.3

Paper	Species	Type of test	Contaminant	Metal	Water Concentration (ug/l)	Surface Sediment Concentration (ug/g)	Root Concentration (ug/g)	Rhizome Concentration (ug/g)	Shoot Concentration (ug/g)
Mays and Edwards 2001	*Typha latifolia*	Field natural wetlands - Spring	Metals	Pb	< 2	1.3	17.9	NR	< 0.09
Mays and Edwards 2001	*Typha latifolia*	Field natural wetlands - Fall	Metals	Pb	< 2	2.1	9.9	NR	0.7
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (IMP)-Spring	Metals	Pb	< 2	1	4.7	NR	< 0.09
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (IMP) - Fall	Metals	Pb	< 2	1.8	6.1	NR	0.6
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (WC)-Spring	Metals	Pb	2.2	2	6	NR	1.1
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (WC)-Fall	Metals	Pb	2.2	1.8	8.2	NR	0.8
Mays and Edwards 2001	*Typha latifolia*	Field natural wetlands - Spring	Metals	Zn	< 9	3.7	34	NR	38
Mays and Edwards 2001	*Typha latifolia*	Field natural wetlands - Fall	Metals	Zn	< 9	2.9	34	NR	12

Paper	Species	Type of test	Contaminant	Metal	Water Concentration (ug/l)	Surface Sediment Concentration (ug/g)	Root Concentration (ug/g)	Rhizome Concentration (ug/g)	Shoot Concentration (ug/g)
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (IMP)-Spring	Metals	Zn	< 9	1.4	41	NR	16
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (IMP) - Fall	Metals	Zn	< 9	2.6	23	NR	7.5
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (WC)-Spring	Metals	Zn	30	2.5	16	NR	16
Mays and Edwards 2001	*Typha latifolia*	Field constructed wetlands (WC)-Fall	Metals	Zn	30	2.6	23	NR	12
Siyaraj and Shutes 2001	*Typha latifolia*	Field natural wetland	Cd, Pb, Cu, Zn	Cd	0.4 - 1.65	1.14 - 44.39	~10	~2	~1
Siyaraj and Shutes 2001	*Typha latifolia*	Field natural wetland	Cd, Pb, Cu, Zn	Cu	0.05 - 2.43	5.78 - 41.50	~15	~5	~2
Siyaraj and Shutes 2001	*Typha latifolia*	Field natural wetland	Cd, Pb, Cu, Zn	Pb	2.80 - 5.65	9.71 - 95.45	~18	~5	~2

Paper	Species	Type of test	Contaminant	Metal	Water Concentration (ug/l)	Surface Sediment Concentration (ug/g)	Root Concentration (ug/g)	Rhizome Concentration (ug/g)	Shoot Concentration (ug/g)
Siyaraj and Shutes 2001	*Typha latifolia*	Field natural wetland	Cd, Pb, Cu, Zn	Zn	n.d. - 13.15	48.46 - 239.81	~42	~22	~15
Taylor and Crowder 1983	*Typha latifolia*	Field natural wetland near smelters	Metals	Ca	NR	8292	1781 - 11574	1209 - 6726	2793 - 23129
Taylor and Crowder 1983	*Typha latifolia*	Field natural wetland near smelters	Metals	Cu	NR	3738	13 - 265	n.d. - 37	n.d. - 11
Taylor and Crowder 1983	*Typha latifolia*	Field natural wetland near smelters	Metals	Fe	NR	24258	777 - 57138	105 - 17162	21 - 333
Taylor and Crowder 1983	*Typha latifolia*	Field natural wetland near smelters	Metals	Mg	NR	6841	882 - 5542	745 - 2782	276 - 2410
Taylor and Crowder 1983	*Typha latifolia*	Field natural wetland near smelters	Metals	Mn	NR	573	16 - 901	16 - 552	21 - 808
Taylor and Crowder 1983	*Typha latifolia*	Field natural wetland near smelters	Metals	Ni	NR	9372	n.d. - 388	n.d. - 80	n.d. - 24

Paper	Species	Type of test	Contaminant	Metal	Water Concentration (ug/l)	Surface Sediment Concentration (ug/g)	Root Concentration (ug/g)	Rhizome Concentration (ug/g)	Shoot Concentration (ug/g)
Taylor and Crowder 1983	*Typha latifolia*	Field natural wetland near smelters	Metals	Zn	NR	343	24 - 572	6 - 65	5 - 33
Ye et al. 1997	*Typha latifolia*	Laboratory	0.05 ug/ml Cu and 0.10 ug/ml Ni for 72 days	Cu	50	NR	435 - 493	NR	44
Ye et al. 1997	*Typha latifolia*	Laboratory	0.05 ug/ml Cu and 0.10 ug/ml Ni for 72 days	Ni	100	NR	317 - 561	NR	66 - 92
Ye et al. 1997	*Typha latifolia*	Field natural wetland (FS)	Metals	Zn	NR	86 ± 14	46 ± 4.6	36 ± 3.4	22 ± 1.1
Ye et al. 1997	*Typha latifolia*	Field natural wetland (FS)	Metals	Pb	NR	26 ± 26	25 ± 8.2	40 ± 36	19 ± 9.8
Ye et al. 1997	*Typha latifolia*	Field natural wetland (FS)	Metals	Cd	NR	1.4 ± 0.3	2.1 ± 0.5	1.7 ± 0.9	0.6 ± 0.3
Ye et al. 1997	*Typha latifolia*	Field natural wetland (SH)	Metals	Zn	NR	909 ± 280	58 ± 8.0	43 ± 9.7	23 ± 3.8
Ye et al. 1997	*Typha latifolia*	Field natural wetland (SH)	Metals	Pb	NR	434 ± 58	35 ± 7.4	2.0 ± 0.5	4.7 ± 0.8
Ye et al. 1997	*Typha latifolia*	Field natural wetland (SH)	Metals	Cd	NR	9.4 ± 3.0	1.0 ± 0.2	0.8 ± 0.1	0.2 ± 0.02

Paper	Species	Type of test	Contaminant	Metal	Water Concentration (ug/l)	Surface Sediment Concentration (ug/g)	Root Concentration (ug/g)	Rhizome Concentration (ug/g)	Shoot Concentration (ug/g)
Ye et al. 1997	*Typha latifolia*	Field natural wetland (CM)	Metals	Zn	NR	1327 ± 52	684 ± 70	376 ± 63	29 ± 2.2
Ye et al. 1997	*Typha latifolia*	Field natural wetland (CM)	Metals	Pb	NR	18894 ± 3390	3628 ± 804	414 ± 107	32 ± 8.2
Ye et al. 1997	*Typha latifolia*	Field natural wetland (CM)	Metals	Cd	NR	26 ± 1.9	17 ± 6.3	1.1 ± 0.4	0.8 ± 0.3
Ye et al. 1997	*Typha latifolia*	Field natural wetland (SG)	Metals	Zn	NR	3009 ± 78	946 ± 137	456 ± 66	122 ± 24
Ye et al. 1997	*Typha latifolia*	Field natural wetland (SG)	Metals	Pb	NR	5686 ± 621	1108 ± 149	354 ± 69	40 ± 11
Ye et al. 1997	*Typha latifolia*	Field natural wetland (SG)	Metals	Cd	NR	20 ± 0.3	1.5 ± 0.1	1.6 ± 0.6	0.6 ± 0.09
Zhang et al. 1990	*Typha latifolia*	Field natural wetland (Welsh Harp flood storage reservoir)	Metals	Cd	8.9	12.4	6	72	28
Zhang et al. 1990	*Typha latifolia*	Field natural wetland (Welsh Harp flood storage reservoir)	Metals	Cu	53.4	220.1	67	1580	840

Paper	Species	Type of test	Contaminant	Metal	Water Concentration (ug/l)	Surface Sediment Concentration (ug/g)	Root Concentration (ug/g)	Rhizome Concentration (ug/g)	Shoot Concentration (ug/g)
Zhang et al. 1990	*Typha latifolia*	Field natural wetland (Welsh Harp flood storage reservoir)	Metals	Pb	36.2	841.2	112	504	224
Zhang et al. 1990	*Typha latifolia*	Field natural wetland (Welsh Harp flood storage reservoir)	Metals	Zn	136.6	778.9	164	540	434
Zhang et al. 1990	*Typha latifolia*	Greenhouse	Metals	Cd	10000	286	662	1669	613
Zhang et al. 1990	*Typha latifolia*	Greenhouse	Metals	Cu	10000	187	190	1188	329
Zhang et al. 1990	*Typha latifolia*	Greenhouse	Metals	Pb	10000	168	242	976	532
Zhang et al. 1990	*Typha latifolia*	Greenhouse	Metals	Zn	10000	294.8	689	1800	512

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